BIOLOGICAL SURVEY

of the

ST. MARY'S RIVER

by the

ONTARIO WATER RESOURCES COMMISSION

in co-operation

with the

INTERNATIONAL JOINT COMMISSION

1968

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A biological survey undertaken in 1967 by the Ontario Water Resources Commission in co-operation with the International Joint Commission.

by
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TABLE OF CONTENTS

INTRODUCTION

The St. Mary's River is the connecting waterway between Lake Superior and Lake Huron. The river is divided into several channels by three main islands, namely Sugar Island, Neebish Island and St. Joseph Island (Fig. 1). These channels in several places broaden out to form lakes and bays. Lake George, for example, is approximately eight miles long and two and one-half to four miles wide. The river bottom varies from being rocky in areas of rapid flow to clay and silt in the slow-flowing sections.

The volume of flow averages about 73,000 cfs and fluctuates little because flow is controlled by the Compensating Works Dam located at Sault Ste. Marie. The rate of flow along most of the river is slow enough for navigation, except at the St. Mary's Falls (Sault Ste. Marie) where ship locks permit commercial and pleasure boats to pass through.

There are only two urban centres on the St. Mary's River - Sault Ste. Marie (Ontario) and Sault Ste. Marie (Michigan), both located at the St. Mary's Falls. More than half the working force of Sault Ste. Marie (Ontario) is employed by the Algoma Steel Corporation in that city. Many others are employed by other industries, such as the Abitibi Power and Paper Company and the Mannesman Tube Company. The city is, therefore, primarily an industrial centre.

The St. Mary's River, because of its location on the Great Lakes system, serves an important role in commercial

navigation. In addition, it is used as an industrial and public water supply, for hydro power generation, waste assimilation, and for recreation, boating, waterfowl hunting and fishing. It is important that water quality be kept to a high standard because of the river's multiple use potential.

On the American side, there are no significant industrial waste discharges to the river. On the Canadian side, however, four industries discharge either directly or indirectly into the St. Mary's River - the Algoma Steel Corporation, the Abitibi Power and Paper Company, the Mannesman Tube Company and the Dominion Tar and Chemical Company (Domtar) (Fig. 1). Downstream from Sault Ste. Marie (Ontario) the effluent from the city's sewage treatment plant enters the river.

The following survey was conducted in July and August, 1967, in order to establish the quality of water and sediment in the river and to determine to what extent the waste discharges are causing impairment. All but the lower reaches of the river were studied (Fig. 2).

METHODS

Primary attention was devoted to the benthic populations of the St. Mary's River. A total of 89 stations were sampled using a Ponar dredge. Two dredge samples were collected at each of 80 stations, and one sample was collected at each of the remaining nine stations. The invertebrates were separated from the sediment using a 24-mesh screen (0.65 mm aperture), were subsequently preserved in 95% ethanol and returned to the laboratory for enumeration and identification.

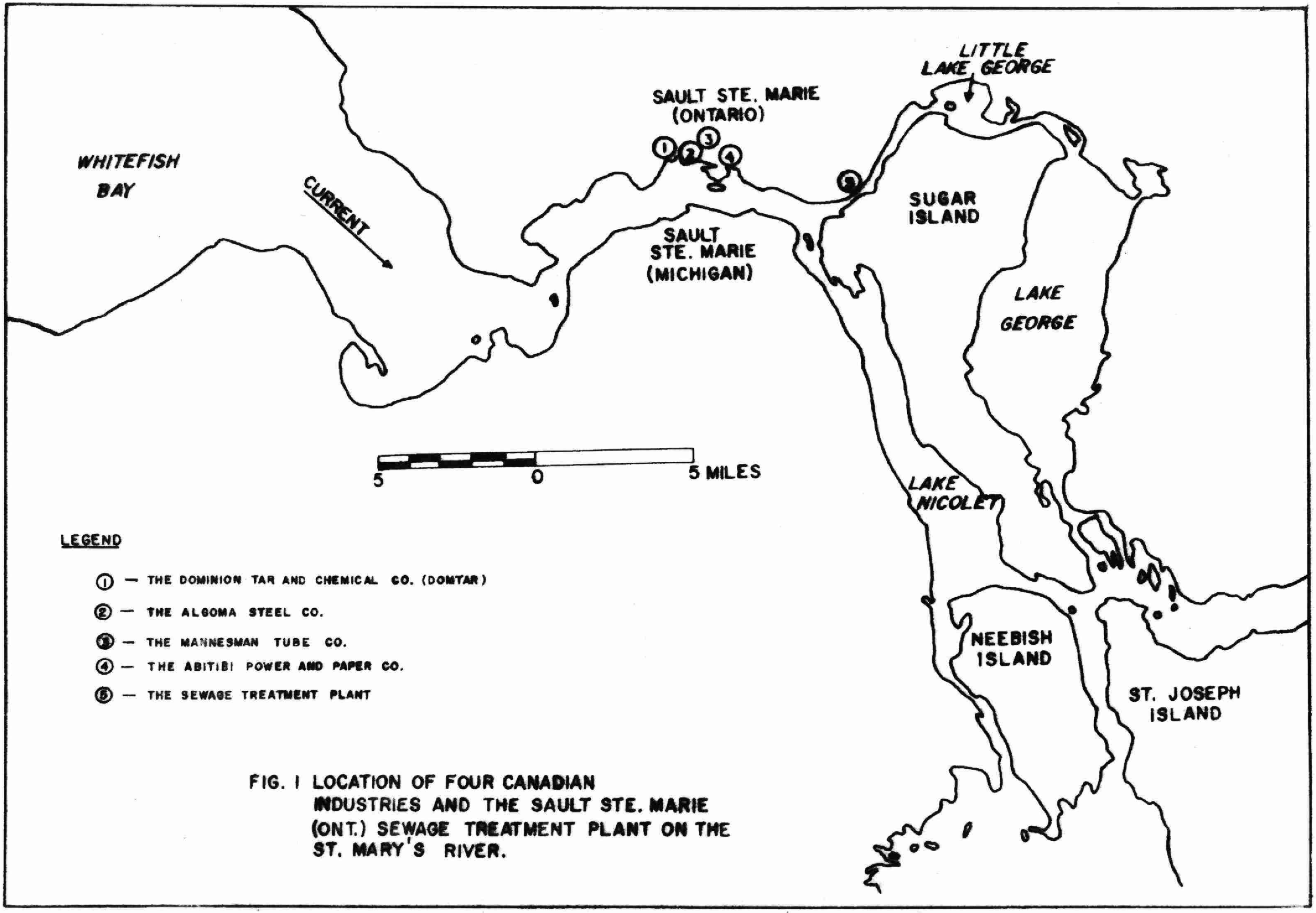

FIG. I LOCATION OF FOUR CANADIAN INDUSTRIES AND THE SAULT STE. MARIE (ONT.) SEWAGE TREATMENT PLANT ON THE ST. MARY'S RIVER.

At each station, physical characteristics of the sediment were described and selected sediment samples were retained for further physical examination and/or chemical analyses. In order to determine relationships between water quality and the character of the sediments, chemical tests were conducted on the water at these stations, following shipment to the OWRC laboratory at Toronto.

RELATIONSHIPS OF BOTTOM FAUNA TO WATER QUALITY AND SEDIMENT CHARACTERISTICS

Investigations of benthic fauna are useful in measuring water quality. One of the most significant features of the macroinvertebrate population is that it is very stable in both quality and quantity relative to the chemical and bacteriological characteristics of water. Macroinvertebrates respond gradually to changes in water quality characteristics except in extreme cases where a toxic material suddenly kills certain species or the whole population. A biological survey, therefore, not only gives an indication of water quality at the time of the investigation, but it gives a long-term indication of what the quality of water has been prior to the investigation.

Another important aspect of investigating the benthos is that the population structure may be changed when the sediment becomes altered by a foreign material, such as the settling of iron oxide particles. In such cases analyses of water samples may show no impairment, while fish production may be reduced by disruption of the normal biological food chain.

In general, the response of benthic communities to the characteristics of the water and sediment is not unlike the response of any biological population to its environment. Some species are killed by pollutants, others thrive and become abundant in organically-enriched environments. Most species of mayfly nymphs and caddisfly larvae, for example, cannot live in an organically-polluted environment, while many species of tubificid worms are tolerant to heavy organic enrichment and become very abundant with the lack of competition and with excess food. A clean-water community is usually characterized by a wide variety of species, with no one species dominating. In a polluted environment, only a few species are found, all of which are pollution-tolerant, and tubificid worms often reach very high population densities.

The bottom fauna varies according to natural characteristics of a body of water, such as depth, temperature, and type of sediment. For this reason, experience is necessary to determine whether abnormal communities are caused by natural or man-made influences.

RESULTS

Appendix I lists the macroinvertebrates found at each station, and Appendix II lists the results of chemical tests conducted at selected stations.

For purposes of illustration and comparison, the study area was divided into six sections - A, B, C, D, E and F (Fig. 2).

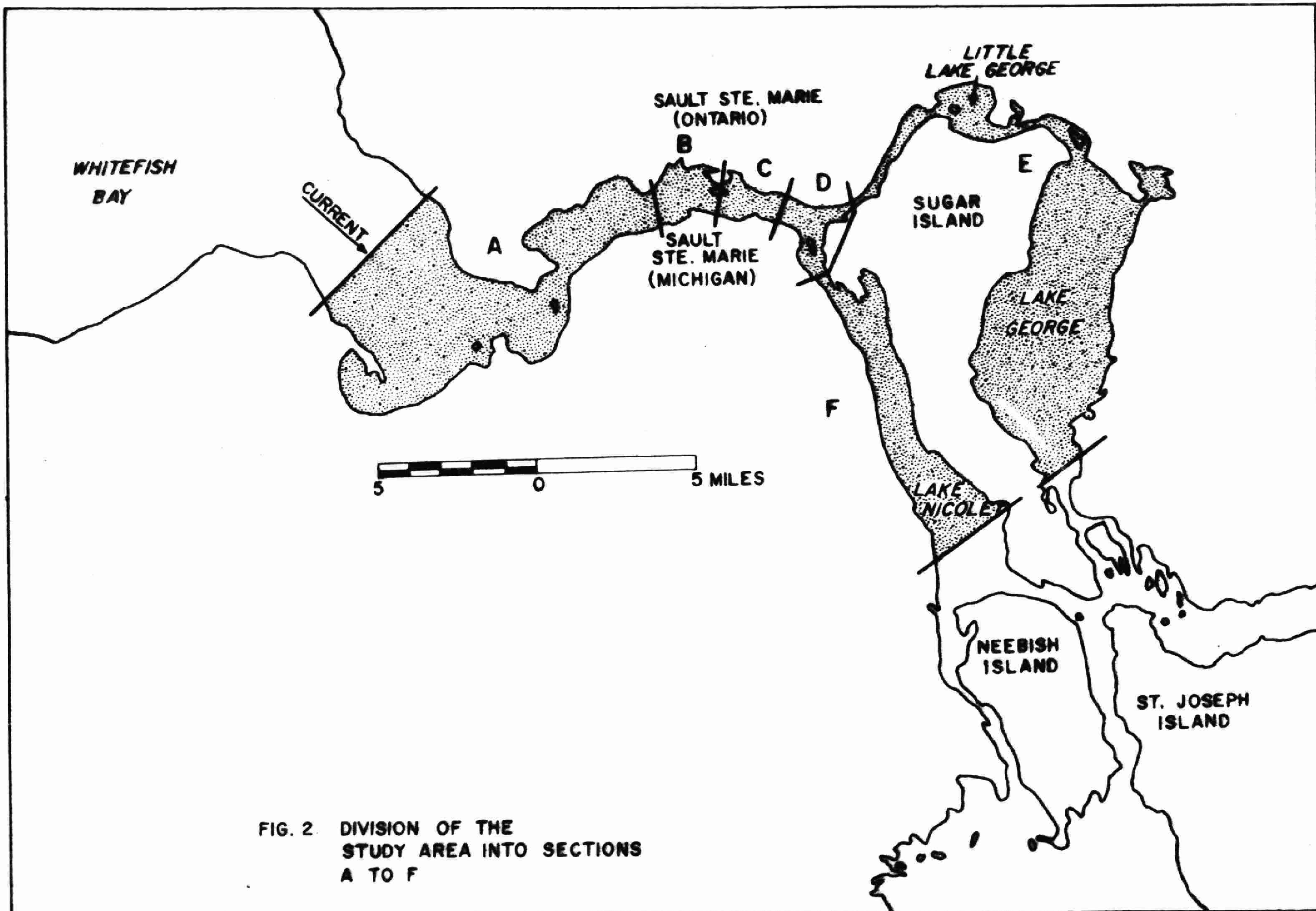

FIG. 2 DIVISION OF THE STUDY AREA INTO SECTIONS A TO F

Section A

Figure 3 shows the locations of the fourteen stations sampled in Section A. Data collected from these stations indicated that the water quality in this area was good. No impairment was detected from any of the biological or chemical measurements.

The benthic communities were characterized by a wide variety of species and the common occurrence of organisms which can live only in clean water. Mayflies and caddisflies, which are sensitive to pollution, were found at seven stations and eight stations respectively. Three genera of mayflies (*Hexagenia*, *Ephemera*, *Caenis*) were found, along with four genera of caddisflies (*Oecetis*, *Mystacides*, *Polycentropus*, *Phryganea*). Amphipods, another relatively intolerant group of organisms, were recovered at 11 stations; *Pontoporeia affinis* and *Hyalella azteca* each occurred at six stations. Tubificid worms, which often become abundant in polluted environments, were found only in low densities, ranging from 0 to 729 per M^2. A relatively wide variety of species were recovered, including *Potamothrix vejdovskyi*, *Aulodrilus americanus*, *A. pigueti*, and *Psammoryctides curvisetosus*, none of which are normally found in impaired water. Similarly midge larvae, which also tend to become abundant in organically-enriched areas, were characterized by low densities and wide variety of species.

In addition, chemical parameters indicated good water quality (Appendix II). Total phosphate (as PO_4), total kjeldahl, solids and phenols were all relatively low. Also,

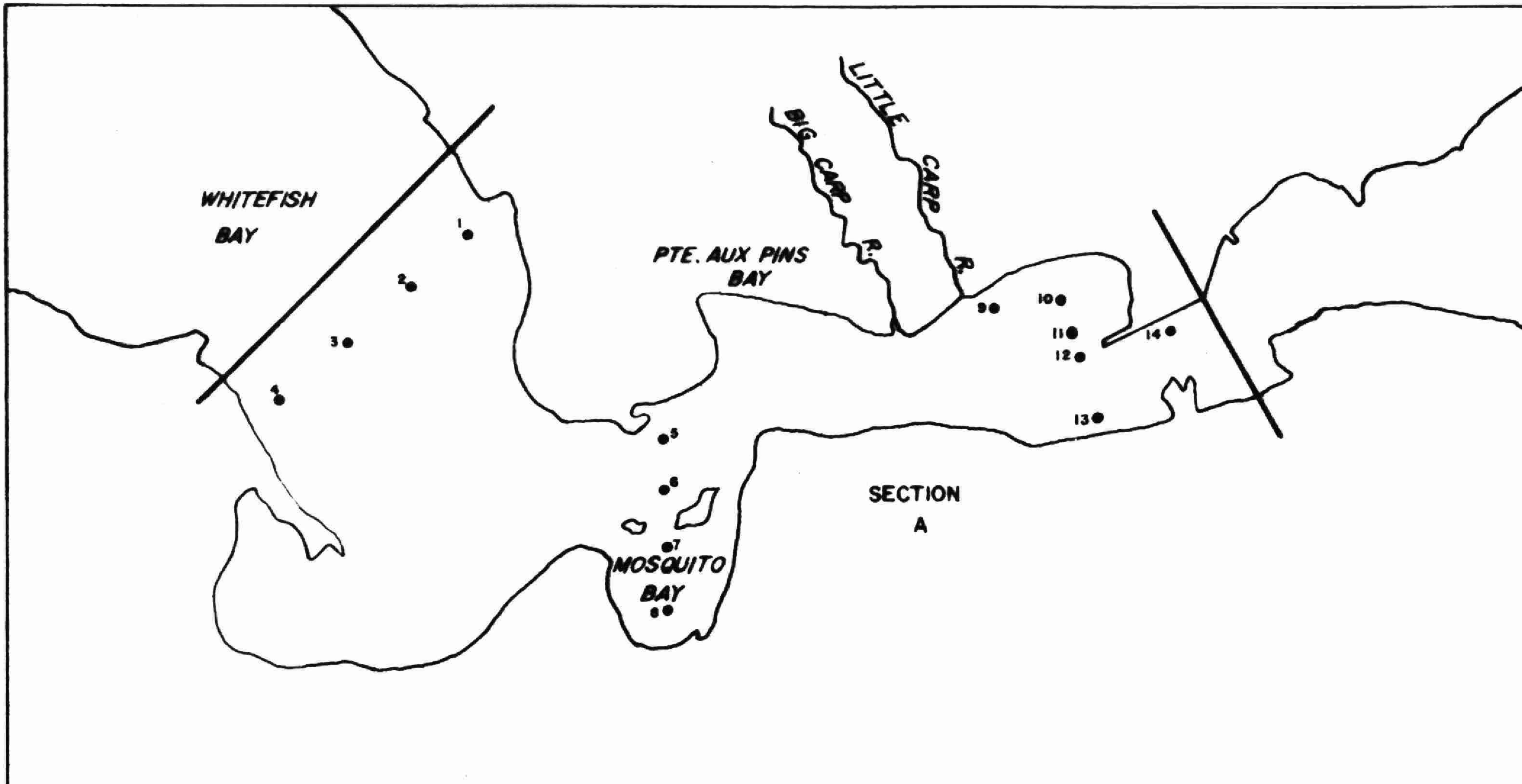

FIG.3 LOCATION OF THE 14 STATIONS SAMPLED IN SECTION A

no oil slick, sediment odour, wood particles or iron oxide particles were found in the sediment, nor was any other visual impairment noted.

Section B

Figure 4a shows the locations of sampling stations in section B, as well as the locations of industrial waste outfalls. The Algoma Steel plant discharges cooling water and waste materials at several locations. At locations 1 and 3 (Fig. 4a), effluents enter Davignon Creek after passing through oil separators. Effluents 5 to 9, located at the head of the loading dock, carry mainly cooling water, but some waste materials are contained in these discharges as well (e.g. phenols, solids). Effluent 10 carries a high concentration of solids, most of which is iron oxide. Discharges 11 and 12 carry cooling water, but again some waste materials are discharged. The effluent at 12 is passed through an oil separator before being released into the river.

The Mannesman Tube Company discharges to Davignon Creek at location 2, and the Dominion Tar and Chemical Company discharges to Bennet Creek at location 4.

The bottom fauna in this section of the study area was found to be disrupted at several stations owing mainly to three waste materials in the sediment - iron particles, wood particles and oil. Figures 4b, 4c, 4d and 4e illustrate the areas where wood particles, high iron oxide concentrations and oil were found in the sediment.

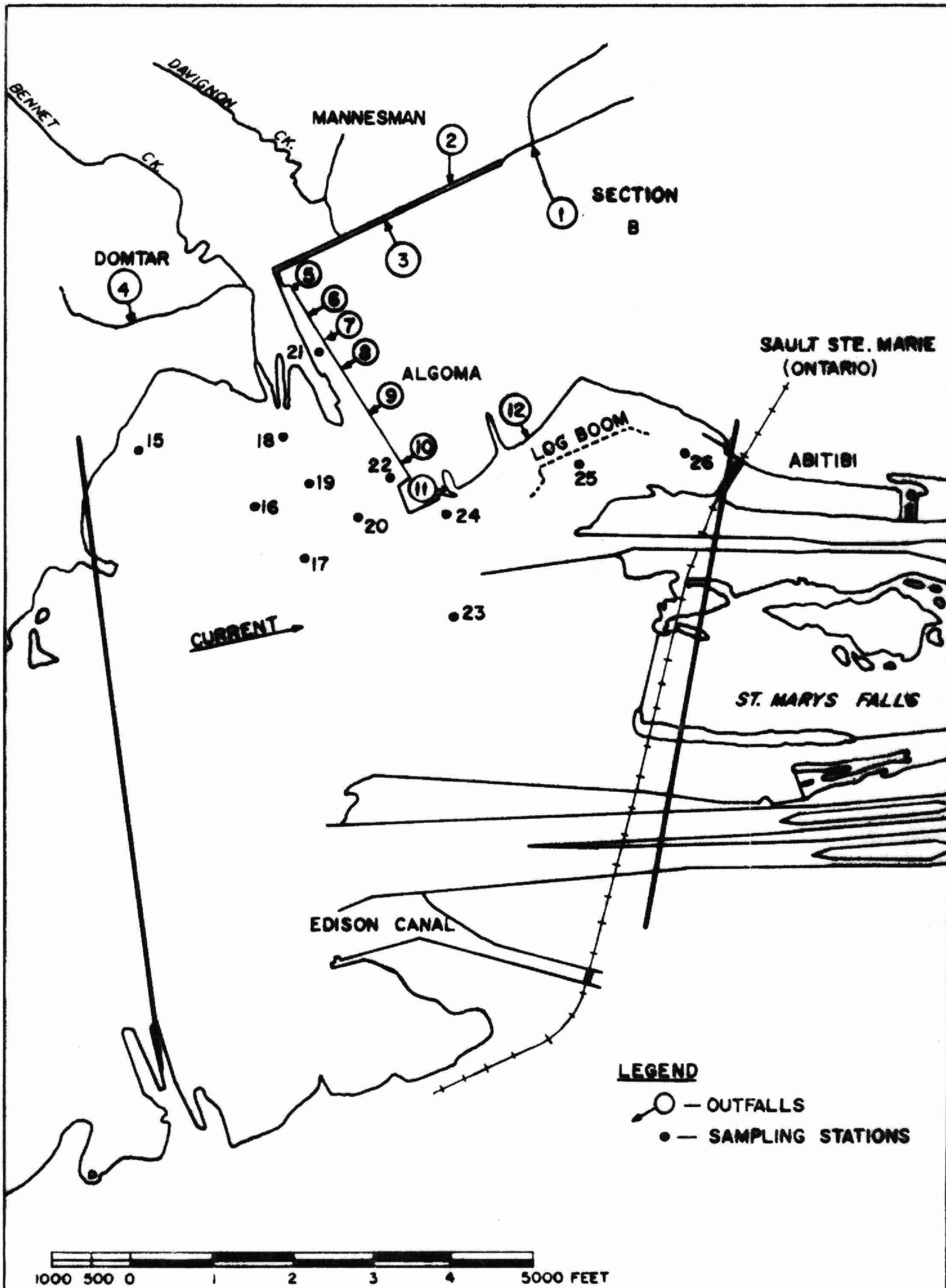

FIG. 4 a INDUSTRIAL OUTFALLS AND SAMPLING STATIONS IN SECTION B

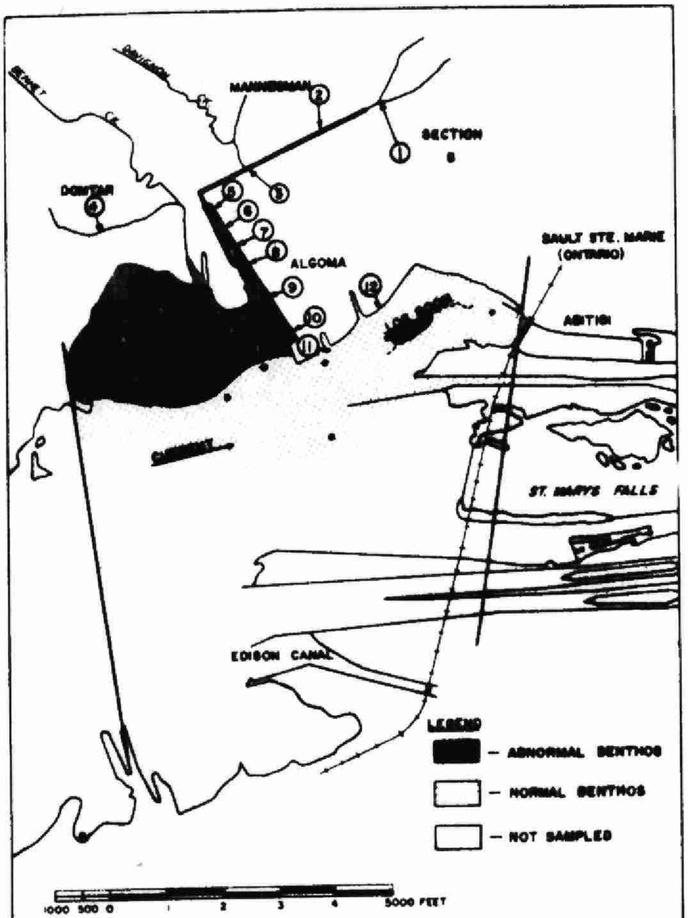

FIG. 4b BENTHIC COMMUNITY STRUCTURE

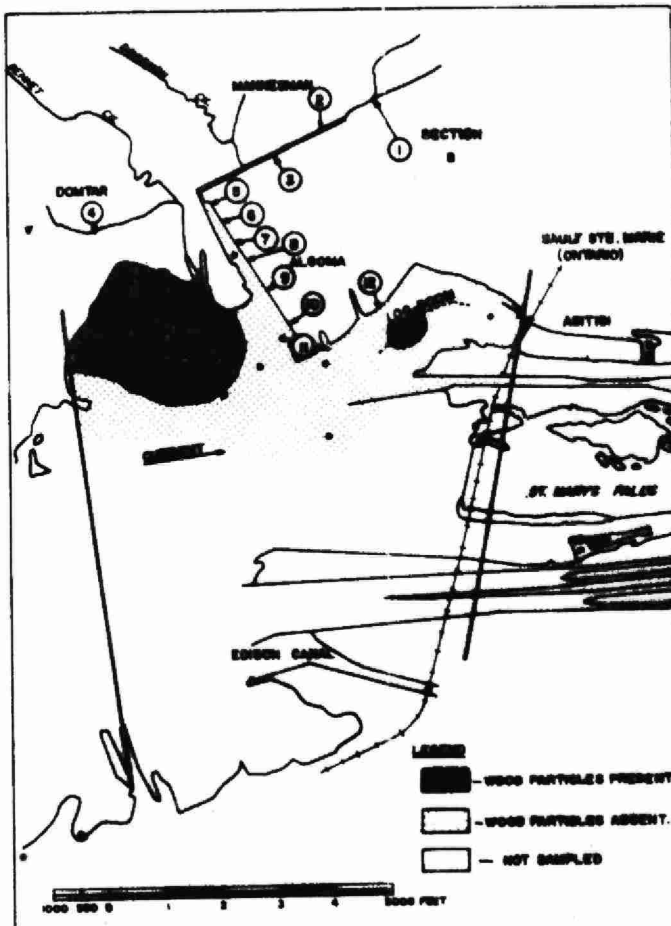

FIG. 4c WOOD PARTICLE DEPOSITION

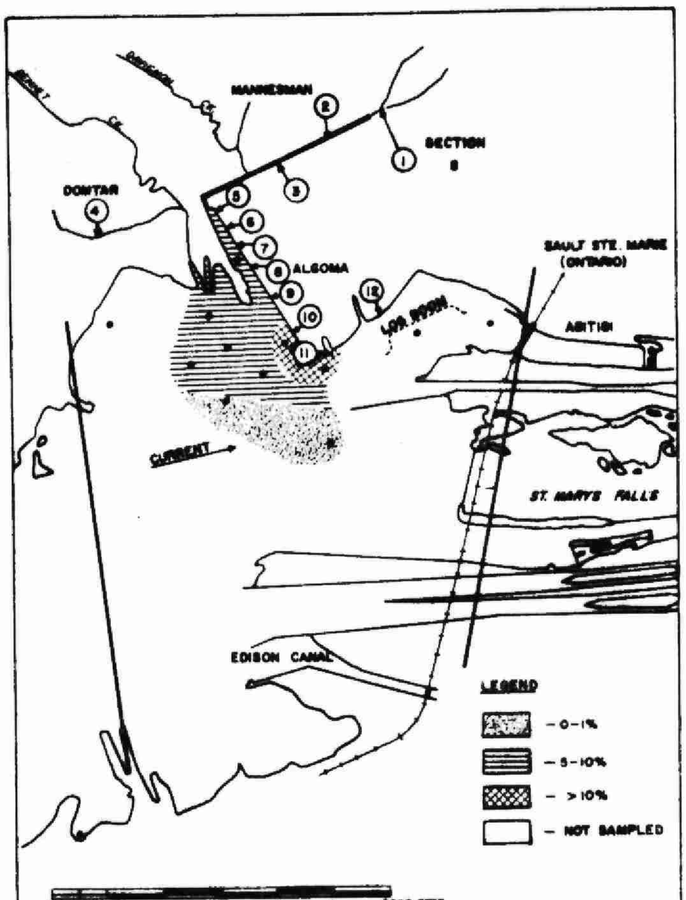

FIG. 4d IRON (Fe_2O_3) CONCENTRATIONS IN THE AIR-DRIED SEDIMENT.

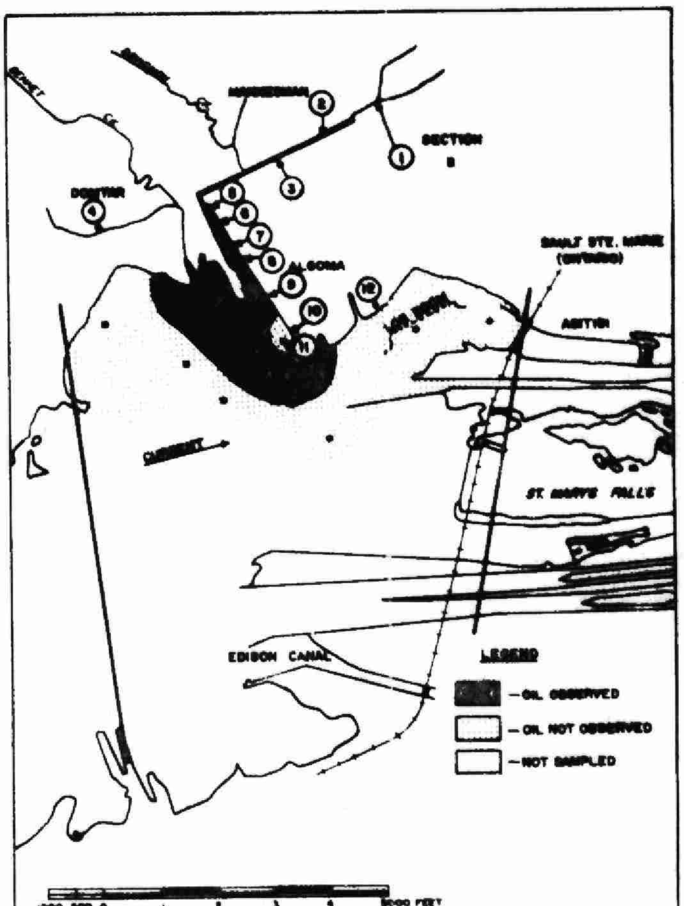

FIG. 4e OIL IN THE SEDIMENT.

Station 21, located near the middle of Algoma's loading dock (Fig. 4a), contained only tubificid worms, all of which were pollution tolerant - Tubifex tubifex, Limnodrilus hoffmeisteri, and L. cervix. An oil slick was noted on the water's surface at this station, and oil was found in the sediment. There was also a considerable amount of iron oxide in the sediment (6.5%)*, and this iron oxide-oil combination was presumably the major factor in affecting the benthic community.

Station 22 was located near outfall number 10 which carries a high iron concentration. Severe impairment was evident at this station, as no macroinvertebrates were found. The sediment was a reddish-brown colour, and lab tests showed that iron constituted 25% of the sediment weight. Iron oxide particles in the sediment were the main factor in eliminating the macrobenthos in this area.

The normal benthos in the bay (stations 15, 16, 18 and 19 is disrupted primarily by iron oxide, oil and wood particles in the sediment. At station 15, the sediment was blanketed with wood particles, and only pollution-tolerant organisms were found (midges, clams, worms and leeches). Station 18 contained only tubificid worms, all of which were pollution-tolerant (L. hoffmeisteri, T. tubifex and Peloscolex ferox). Oil was noted in the sediment at this station (lab tests showed 1.16% ether-soluble oils), wood particles were observed, and sediment analyses revealed a substantial iron content - 7%. The combination of these three wastes was no doubt largely responsible for the unbalanced benthic community.

* All sediment iron determinations refer to Fe_2O_3 weight of the air-dried sediment.

Similarly, oil, iron (6%) and wood particles were noted at station 19. Only pollution-tolerant worms and midges were found, as well as a snail (*Campeloma*) and clam (*Pisidium*). The sediment at 16 had similar characteristics, and only tubificid worms and midge larvae were found. However, some recovery was indicated, as the tubificids *Aulodrilus pluriseta* and *P. vejdovskyi*, which are normally found only in fairly clean water, were found at this station.

Stations 20 and 24 had more balanced communities, including the pollution-sensitive mayfly *Hexagenia*. However, benthic production was still somewhat impaired. Oil was noticed in the sediment at each of these stations, and iron content was quite high (5% at station 20 and 11% at station 24). The lack of wood particles at these stations probably accounted for the partial recovery that was noted.

The benthic fauna at stations 17, 23, 25 and 26 indicated little or no impairment. The mayfly genus *Hexagenia* was found at station 17, the mayfly genera *Hexagenia* and *Ephemera* were present at station 23, and the caddisfly genera *Hydropsyche*, *Rhyacophila*, and *Dolophilus* at station 26. Station 25 was located near a log boom, and wood particles in the sediment somewhat disrupted normal bottom faunal development. However, the lumbriculid worm *Stylodrilus heringianus* was found, which is quite pollution-intolerant. At all of these stations iron content in the sediment was low (0.9% - 1.7%), no oil was noticed in the sediment, and wood particles were noted only at station 25.

The high iron content in the sediment at stations 16, 18 and 19 indicated that iron oxide particles from effluent #10 had been carried in a westerly direction, to settle out in the bay. This was verified when a small drogue placed in the effluent on a calm day (August 1) was carried into the bay. The coarse iron oxide particles appeared to settle out a short distance from the effluent while the finer particles were predominant further offshore. It is obvious that some iron is carried into the main part of the river, as stations 20 and 24 both had a considerable amount of iron in the sediment.

In order to investigate the thermal effects of cooling water being discharged along the loading dock, temperature readings were taken on surface and bottom water at several locations on August 1. Bottom water along the loading dock was from 3 to 8°C cooler than surface water. This warm surface water probably affects localized phytoplankton production but the effect on the rest of the biota is undoubtedly quite minor.

Section C

This area receives three industrial discharges, shown in Figure 5a. Effluents 13 and 14 carry wastes from the Abitibi Power and Paper Company which contain considerable quantities of wood particles and fibre, and are high in BOD_5, suspended solids, phenol and sulphite. Effluent 15, often referred to as the trunk sewer, carries wastes from the Algoma Steel Corporation. This trunk sewer carries a volume of about 75 mgd, including a variety of pollutants. Some of the major

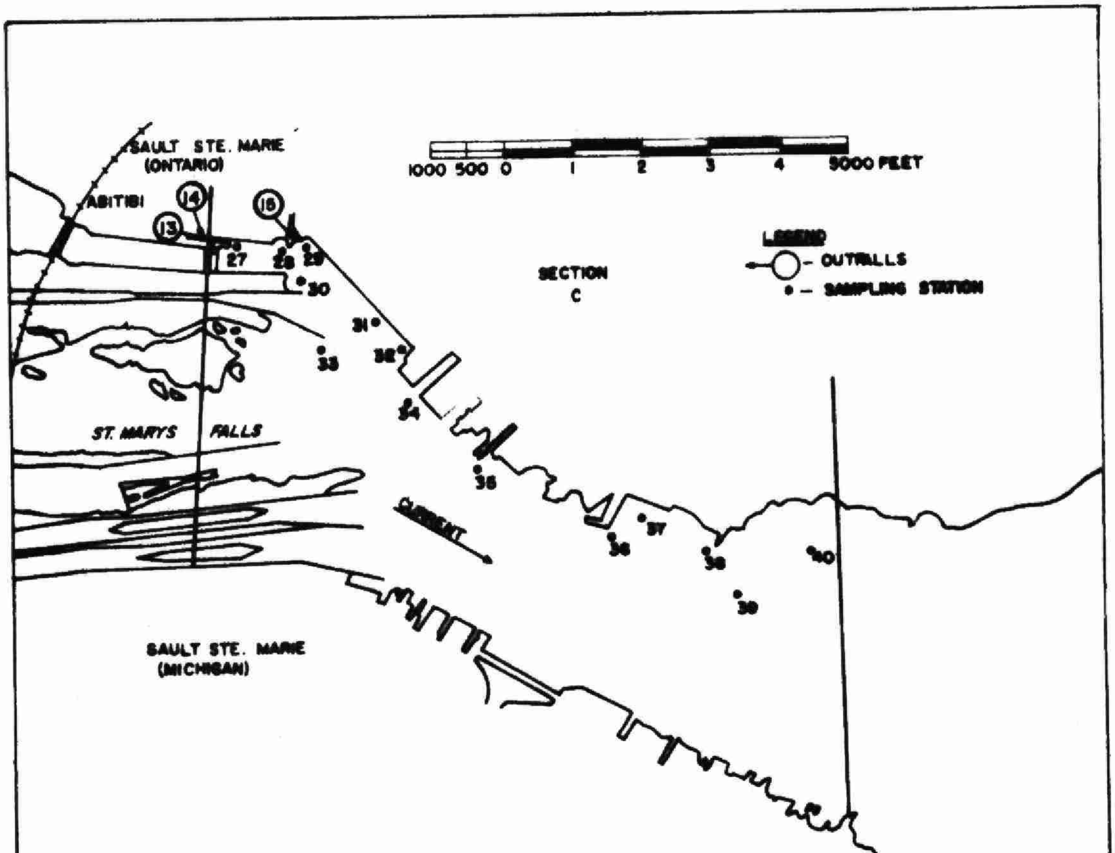

FIG. 5a INDUSTRIAL OUTFALLS AND SAMPLING STATIONS

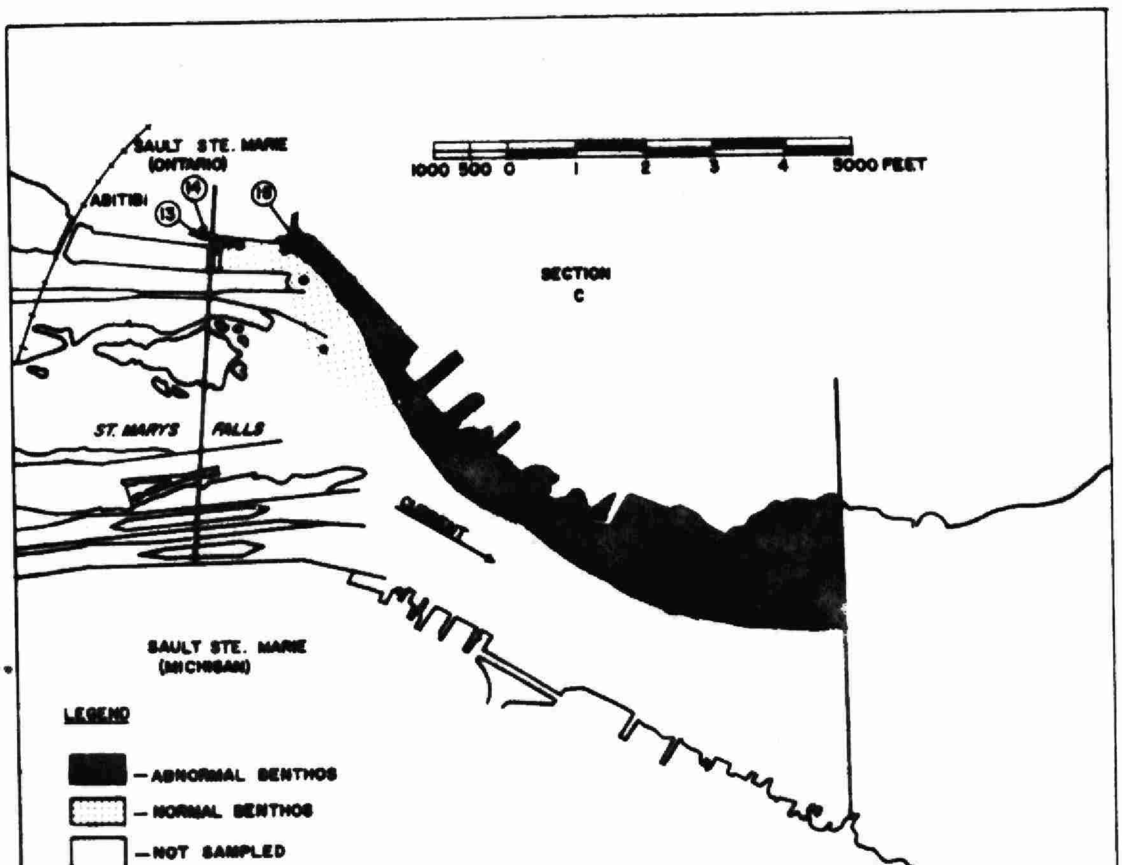

FIG. 5b BENTHIC COMMUNITY STRUCTURE

waste materials are degradable materials with a high BOD_5, suspended solids, oils, phenol, cyanide, ammonia, and iron.

A total of 14 stations were sampled in this section (Fig. 5a). Benthic communities indicative of a polluted environment were evident at all but five of these stations; these five (27, 28, 30, 33, 39) are presumably outside the influence of wastes from the trunk sewer. Impairment in this section is caused primarily by four waste materials associated with the sediment: 1) iron oxide particles 2) wood particles 3) oil and 4) naphthalene. The area of biological degradation and the distribution of these wastes is illustrated in Figures 5b, 5c, 5d, 5e, and 5f.

The area between the Abitibi Power and Paper Plant and the trunk sewer was very difficult to sample because of the rapid water flow. However, some information was gained from samples collected at stations 27 and 28. Station 27, located above the trunk sewer (15) and outside the influence of the Abitibi Power and Paper Company's outfalls, had an abnormal benthos, attributable to the coarse gravel bottom which is subjected to continuous washing and shifting by the current. However, the lumbriculid worm <u>Stylodrilus heringianus</u>, plus a good variety of midge larvae were found, indicating little or no impairment from waste materials. Station 28, located above the trunk sewer but within the influence of Abitibi's outfalls, again had an unfavourable physical environment (coarse, clean gravel). The isopod <u>Asellus</u>, however, which is not found in heavily polluted water, was recovered at this station. The degree of impairment at this distance down-

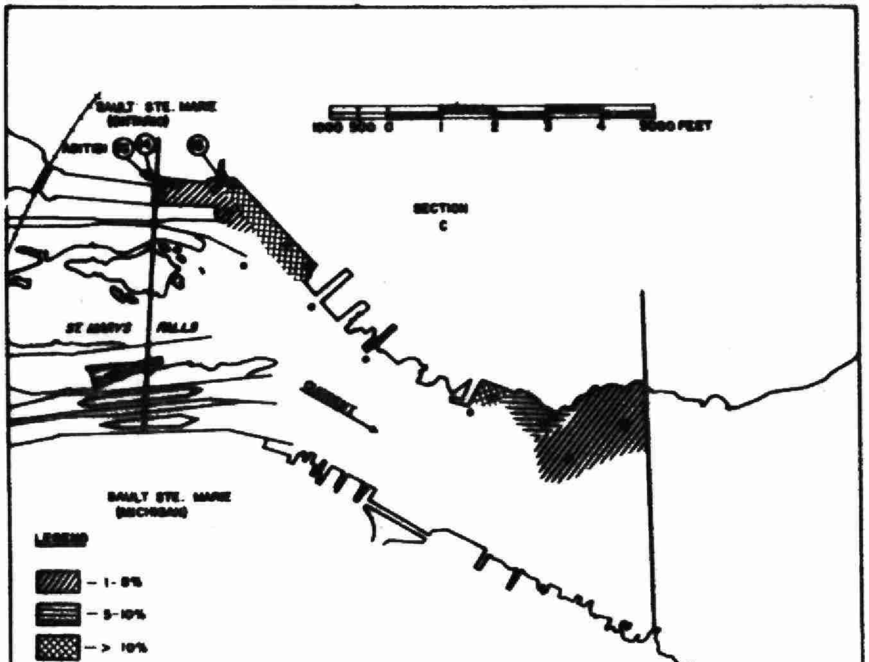

FIG. 5c IRON (Fe_2O_3) CONCENTRATIONS IN THE AIR-DRIED SEDIMENT.

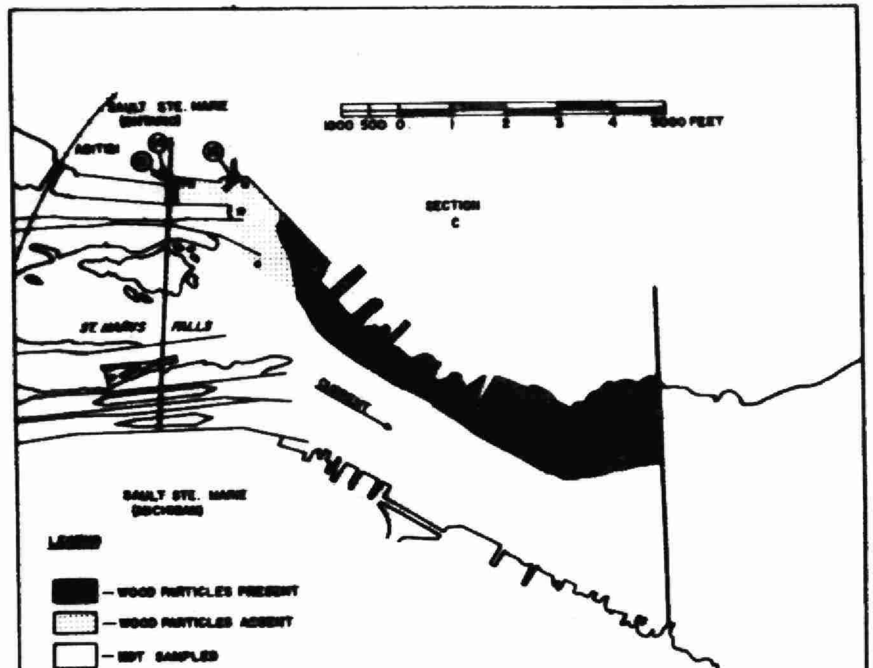

FIG. 5d WOOD PARTICLE DEPOSITION.

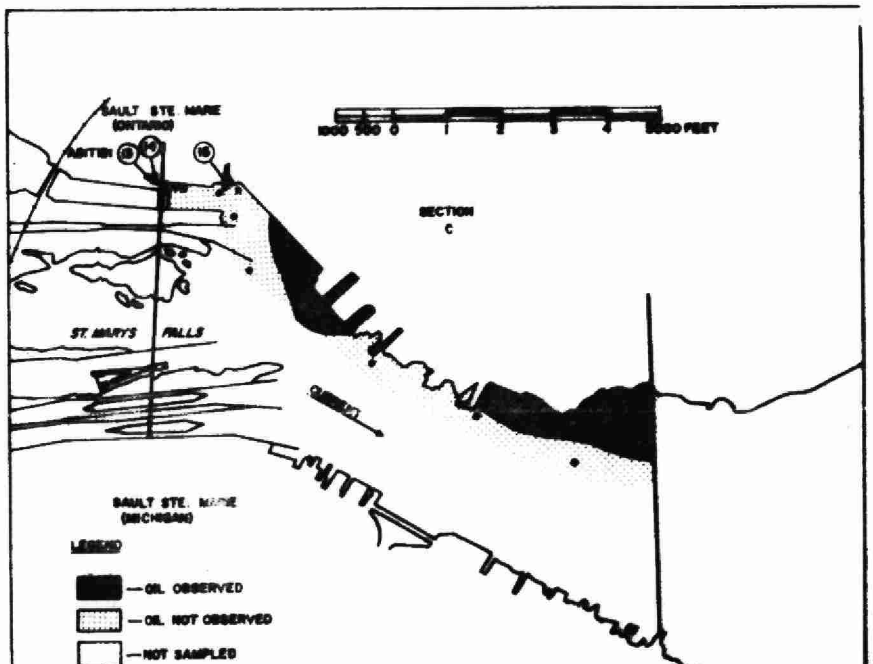

FIG. 5e OIL IN THE SEDIMENT.

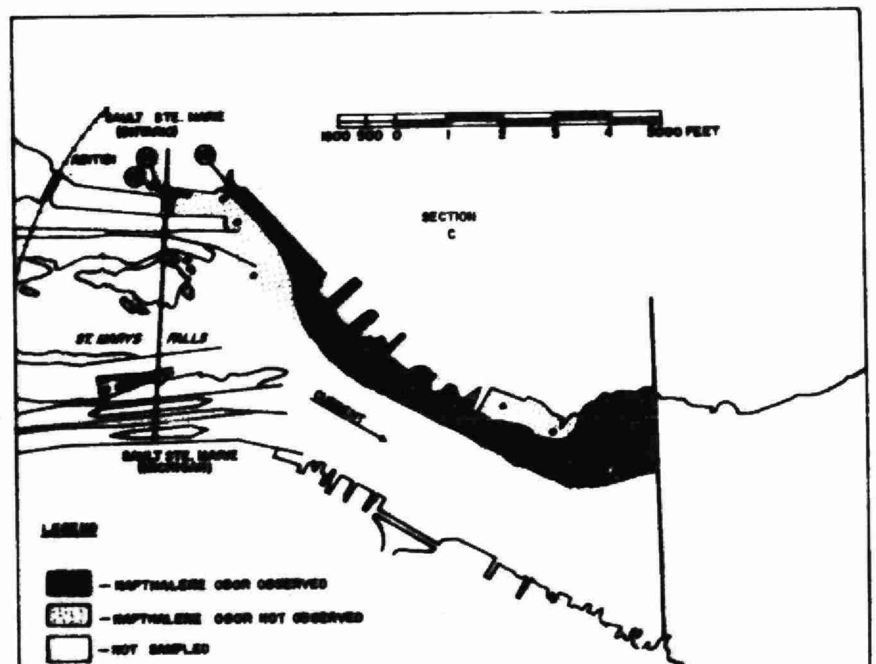

FIG. 5f NAPTHALENE ODOR IN THE SEDIMENT.

stream from Abitibi's wastes was not well determined, but it is believed that impairment is minor. The major impairment from these wastes occurs further downstream where the wood particles and fibre settle out.

Stations 30 and 33, located outside the influence of the industrial wastes, contained the clean-water mayfly genus Hexagenia, as well as a good variety of midges and worms. Good water quality was therefore indicated. None of the chemical measurement indicated water quality impairment.

Wastes from the trunk sewer hug the Canadian side of the river because of the rapid river flow. Stations 29, 31, 32, 34 and 35 were all downstream and within the influence of wastes from the sewer. The benthos was severely disrupted at all of these stations, with pollution-tolerant sludgeworms being the only organisms found. Iron in the sediment, as well as wood particles, fibre, oil and naphthalene probably all play a part in causing this extensive impairment of the benthic community. Station 29, located about 150 feet from the sewer, was entirely void of macroinvertebrates.

Stations 31, 32, 34 and 35 contained only pollution-tolerant species of tubificid worms. Only one species, L. hoffmeisteri, was present at 31 and 34. Stations 32 and 35 contained only L. hoffmeisteri and T. tubifex, and Limnodrilus sp. respectively. Iron constituted 44%, 27% and 30% of the air-dried sediment weight at stations 29, 31 and 32 respectively (no iron analyses were conducted at 34 and 35). Phenol concentrations in the water were high,

ranging from 100 ppb at 29 and 31, to 40 ppb at 35. No wood particles were noted at 29, perhaps because they first start settling out further downstream, but wood particles and fibre were noticed in the sediment at stations 31 to 35, and no doubt contribute to the disruption of the bottom fauna. A distinct naphthalene odour was also noted at all four of these stations.

Pollution was less extensive but still prevalent between stations 36 and 40. While the benthos was limited to pollution-tolerant organisms, a larger variety was found including midge larvae, leeches, lumbriculids, enchytraeids and tubificids. Tubificid worms were restricted to the pollution-tolerant species T. tubifex, L. hoffmeisteri, L. claparedeanus, P. multisetosus and L. profundicola. Iron concentrations in the sediment were lower at these stations, ranging from 3.5 to 12.7% and probably played a less significant role in altering the normal benthos. Phenol concentrations ranged from 30 ppb to 100 ppb, except for station 39 which contained 2 ppb. Wood particles in the sediment were observed at all stations, and a naphthalene odour was detected at 36, 39 and 40. (Infra-red spectroscopic scans from extracts of sediment samples collected in this area in August of 1968 confirmed the presence of naphthalene). Station 39 contained a relatively good variety of organisms, including the lumbriculid S. heringianus, and was probably far enough away from the Canadian shoreline to escape the major zone of pollution.

Section D

Figure 6a illustrates the locations of the 24 stations sampled in this section. Figure 6b illustrates the area of benthic impairment, and figures 6c, 6d, 6e and 6f illustrate

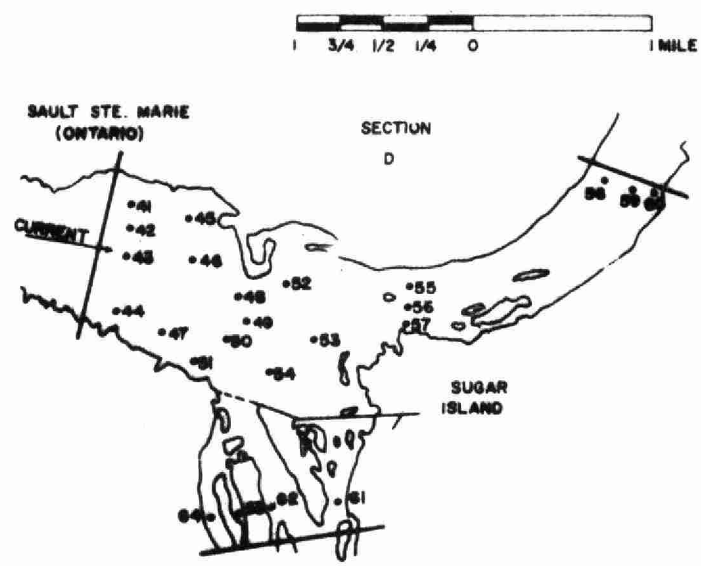

FIG. 6a LOCATION OF THE 24 STATIONS SAMPLED IN SECTION D.

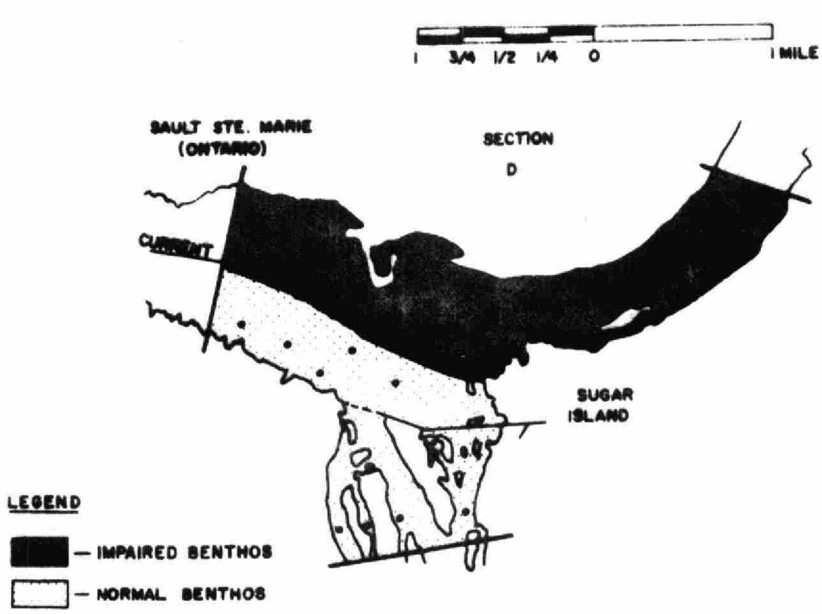

FIG. 6b BENTHIC COMMUNITY STRUCTURE.

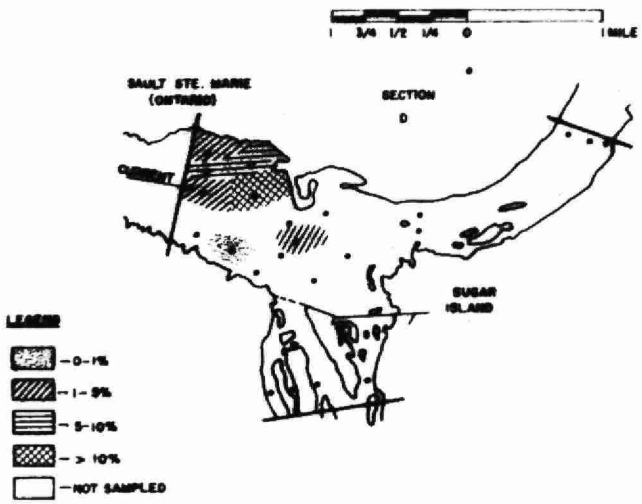

FIG. 6c [illegible] (Fe_2O_3) CONCENTRATIONS IN [illegible] AIR DRIED SEDIMENT.

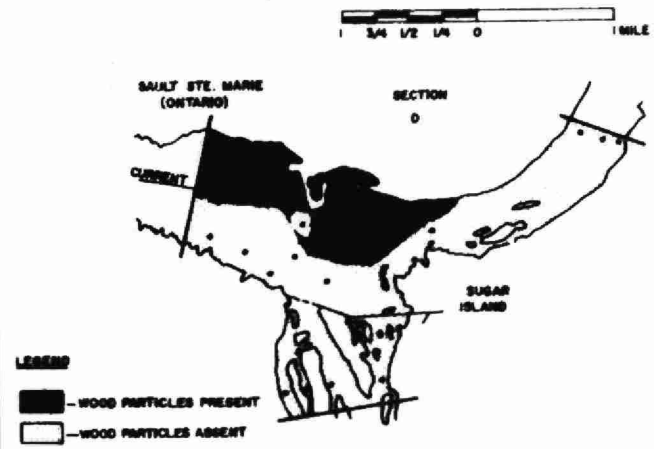

FIG. 6d WOOD PARTICLE DEPOSITION.

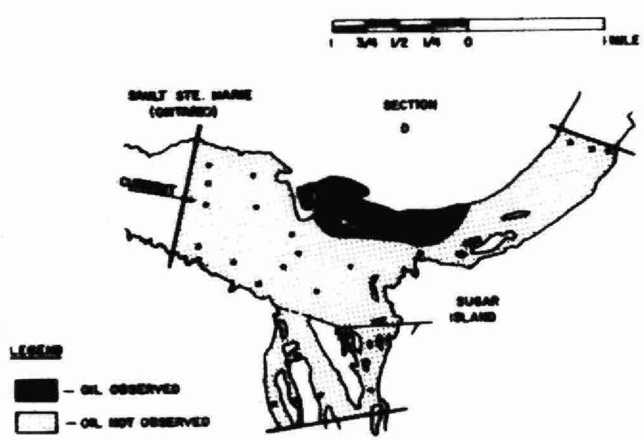

FIG. 6e OIL IN THE SEDIMENT.

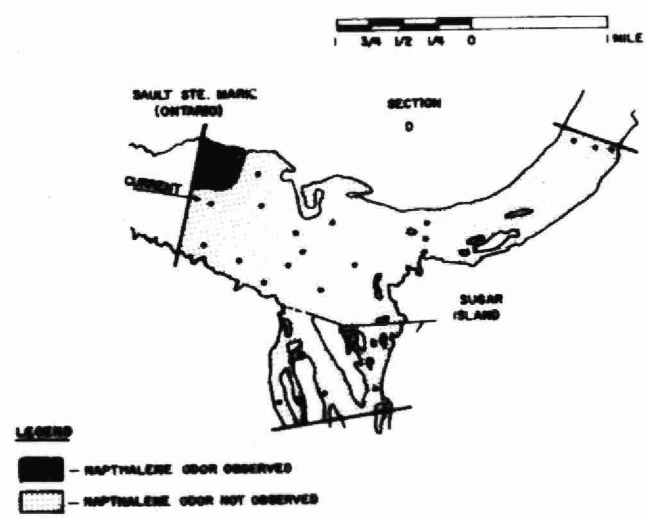

FIG. 6f NAPTHALENE ODOR IN THE SEDIMENT.

the iron concentrations in the sediment and the areas where deposition of wood particles, oil and naphthalene were noted. Benthic populations in this section indicated that the Canadian side of the river can be classed as a recovery zone, while the benthos on the American side reflected good water quality.

At station 41, two pollution-tolerant species of tubificids (L. hoffmeisteri and L. claparedeanus) were the only organisms found. Wood particles were recorded in the sediment, a naphthalene odour was detected, and iron and phenol concentrations in the sediment were 5% and 20,000 ppb respectively. Station 41 was in an area of low flow, and the settling out of wood particles and fibre probably gave rise to a high rate of decomposition and played a major role in disrupting the benthos.

Stations 42, 43, 45 and 46 had a greater diversity of benthic organisms. A wider variety of tubificids were present, including the species A. limnobius and P. curvisetosus, which are not found in heavily polluted water. An amphipod was found at station 42 and an isopod (Asellus) at station 43, along with a good variety of midge larvae. However, no mayflies or caddisflies were found at these stations, and physical impairment of the sediment was still prevalent. Wood particles and fibre were observed at all four stations, iron concentrations reached 10% at station 46, phenol concentrations reached 10% at station 46, phenol concentrations reached 100 ppb in water samples (station 46) and 25,000 ppb in sediment samples (station 42), and a distinct naphthalene odour in the sediment was noted at station 42.

Information from stations 48, 49, 42, 53 and 55 to 60 indicated that recovery was more advanced in this area. Stations 49, 52 and 53 contained a reasonably well-balanced benthos including sludgeworms, midge larvae, snails, clams and isopods. Wood particles and fibre were observed in the sediment at these three stations, but an iron determination for the sediment at station 49 revealed only 1% Fe_2O_3, and no oil or naphthalene odour was detected.

Stations 55, 56 and 57 contained sludgeworms, midge larvae, leeches, crayfish, snails, clams, isopods and amphipods. No wood particles or naphthalene odour was detected in the sediment, and only a slight amount of oil was observed. The bottom fauna at stations 58, 59 and 60 was similar to that found at stations 55-57. A relatively wide variety of macroinvertebrates was found, including the lumbriculid *S. heringianus*. However, wood fibre was noted in the sediment at station 59, and the absence of mayflies and caddisflies suggests that recovery was not complete even at this distance (about 5 miles) from the trunk sewer.

No impairment of water quality was observed on the American side of the river (stations 44, 47, 50, 51, 54, 61, 62, 63, and 64). A well-balanced fauna with a wide variety of organisms was found in this area, as well as the common occurrence of clean-water organisms. The mayfly genus *Hexagenia* was found at five of the nine stations, and the genus *Ephemera* at two stations. Caddisflies, including the genera *Trianodes* and *Caenis*, were found at two stations. Sludgeworm and midge larvae populations were represented by a wide

variety of species, including several types which are restricted to clean-water habitats. No wood particles or fibre were observed in the sediment at any of these stations, nor was oil or naphthalene odour. An iron determination at station 47 showed 0.16% Fe_2O_3 in the sediment. It is evident that industrial wastes from the Canadian side do not impair the benthos along the western channel of Sugar Island.

Section E

This section of the river receives the effluent from Sault Ste. Marie's sewage treatment plant. A total of 19 stations were sampled in this area (Fig. 7a). Stations 65 to 73 were selected to study the effect of the wastes from the sewage treatment plant on the river.

A small drogue was placed in the discharge in order to trace the path of flow of wastes from the sewage treatment plant; stations 65 to 70 were selected along this path. The drogue study was conducted on a very calm day (August 13), and it is believed that the flow pattern was traced with reasonable accuracy.

Heavy organic pollution was evident at stations 65 to 69, station 65 being 100 feet from the outfall, and 69 being 1800 feet from the outfall. These stations supported dense tubificid populations, and the benthic community was restricted to pollution-tolerant organisms (Fig. 7b). Station 65 contained only tubificid worms (L. hoffmeisteri and L. udekemianus); the population density was 2000 per M^2.

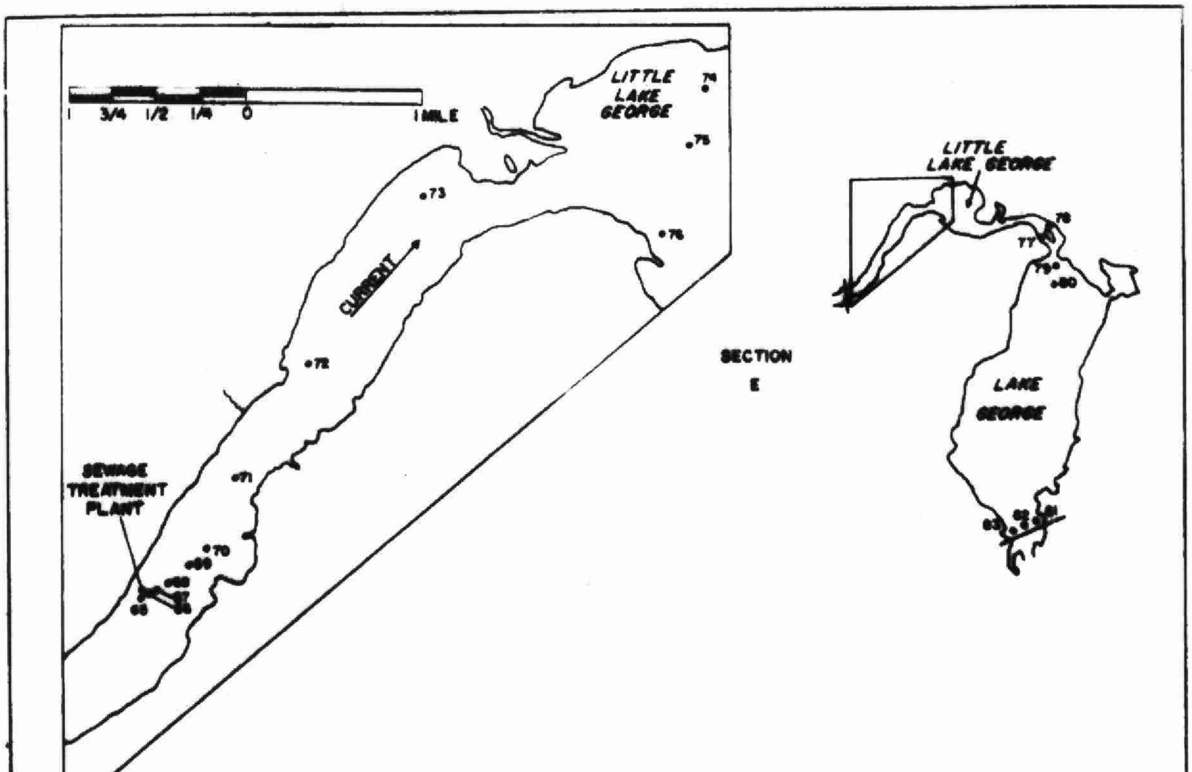

FIG. 7a LOCATION OF THE 19 STATIONS SAMPLED IN SECTION E.

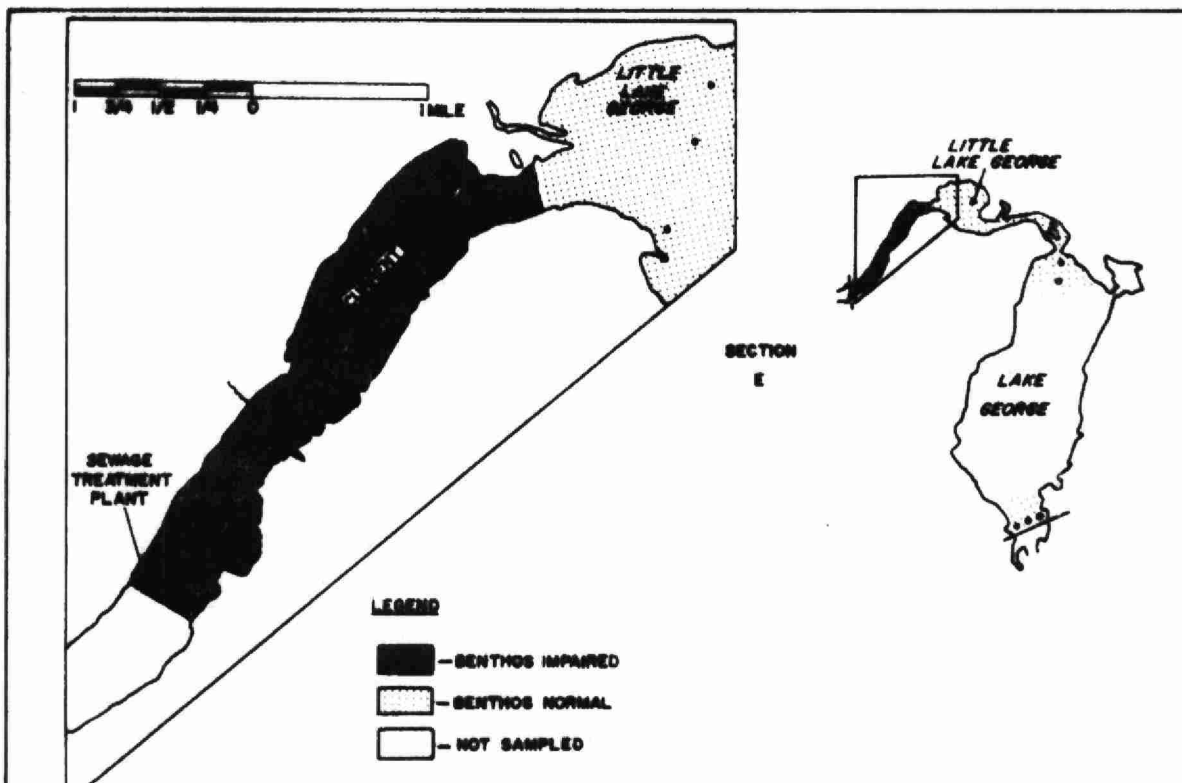

FIG. 7b BENTHIC COMMUNITY STRUCTURE

A high rate of decomposition in the sediment was indicated, as large amounts of gas were released when the anchor and dredge hit bottom. There was a distinct sewage odour to the sediment, and lab tests on surface water samples showed a BOD_5 of 15 ppm, a phenol concentration of 30 ppb, and a free NH_3 concentration of 4.6 ppm. Station 66 (300 feet from outfall) also contained only tubificid worms (L. angustipenis, L. hoffmeisteri, and T. tubifex), reaching a population density of 8300 per M^2. A large amount of gas was again emitted at this station as the dredge hit bottom, indicating heavy decomposition.

Organic pollution was still prevalent at stations 67 (600' from outfall), 68 (1000' from outfall, and 69 (1800' from outfall). While tubificid densities were extremely high at these stations (45,000 per M^2 at 67, 63,000 per M^2 at 68), pollution-tolerant genera of clams (Pisidium) and snails (Physa) were found. Gas emerged from the sediment at station 67 when the dredge hit bottom, and tests on water samples showed a BOD_5 reading of 6.3 ppm and a free NH_3 concentration of 0.05 ppm. Station 69 contained only tubificid worms, all of which were pollution-tolerant (L. hoffmeisteri, T. ignotus, P. ferox). The population density, however, was reduced to 800 per M^2.

Recovery was evident at stations 70 and 71 (2500 feet and 4600 feet from outfall), and the benthos at 72 (8500 feet from outfall) was similar to that found just upstream from the sewage treatment plant outfall. Stations 70 and 71 contained a good variety of organisms including the lumbriculid

S. heringianus, leeches, the snail genus Campeloma, and fingernail clams (Pisidium). At station 72, little or no effect from the sewage treatment plant could be substantiated; tubificids, lumbriculids, leeches, clams and isopods were found, similar to the situation at stations 58 to 60. Similarly, only minor impairment was noticed at station 73, probably from the combined effect of the industrial and sewage treatment plant effluents. Some wood fibre was observed in the sediment at this station, and a high worm population (24,000 per M^2) was found. The benthic community, however, supported a variety of organisms, including leeches, clams, snails and isopods.

Wastes from the sewage treatment plant enter the river before there is complete recovery from wastes discharged upstream by the Algoma Steel Corpn., (trunk sewer) and the Abitibi Power and Paper Co., and total recovery is therefore further delayed. The normal benthic community between the sewage treatment plant and Little Lake George is altered probably by a combination of these industrial and municipal wastes.

Complete recovery of the benthos was not evident until Little Lake George was reached (approximately 10 miles from the industrial waste effluents). Stations 74 to 83 contained a wide variety of organisms, including clean-water mayflies Hexagenia, Ephemera, Caenis) and caddisflies (Polycentropus). Similar to the benthos upstream from Sault Ste. Marie, a wide variety of species was found, with low populations of pollution-tolerant tubificids and midge larvae. No chemical tests were

conducted at these stations, but visual observations indicated good water quality. Iron oxide particles, wood particles, oil, and naphthalene odours were not observed in the sediment.

Section F

Figure 8 gives the locations of the six stations sampled along the west channel of Sugar Island. The benthos along this channel indicated a clean-water environment. The fauna were similar to those found upstream from Sault Ste. Marie. Clean-water mayflies and caddisflies were commonly found, the macroinvertebrate communities were well-balanced, and no physical impairment of the water or sediment was noted. The wastes from Sault Ste. Marie, Canada, obviously do not affect the bottom fauna in this area. Although an examination of waste effluents from Sault Ste. Marie, Michigan, was not carried out, no impairment was found on the American side of the river, and hence any wastes from the American side of the study area must have, at most, a minor effect on the river.

DISCUSSION AND SUMMARY

Water entering the St. Mary's River from Lake Superior is of excellent quality. Biological and chemical measurements and observations at stations upstream from Sault Ste. Marie indicate clean-water conditions.

The major demonstrable impact of pollution entering the St. Mary's River at Sault Ste. Marie is in altering the suitability of the river for supporting game fish populations.

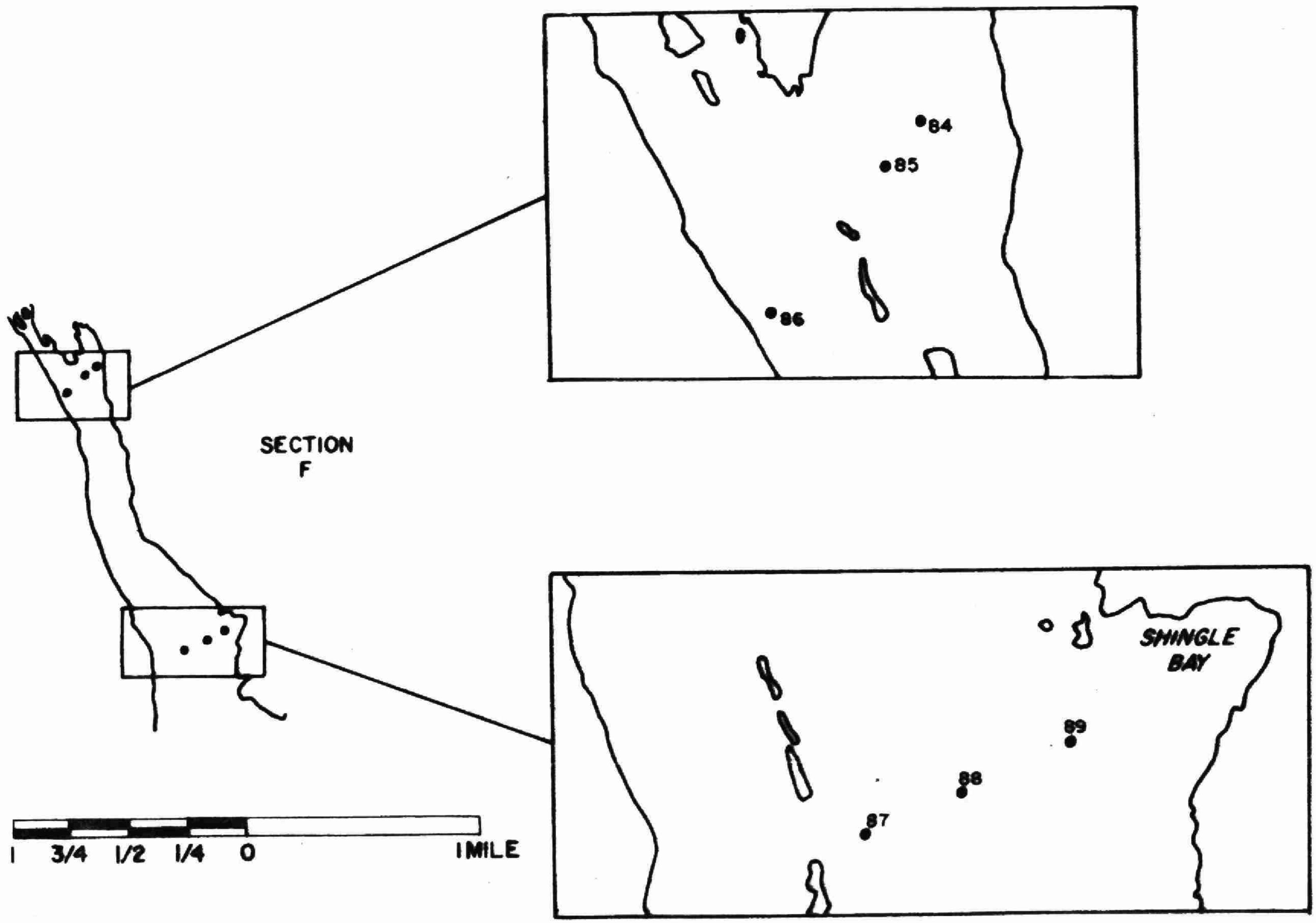

FIG. 8 LOCATION OF THE SIX STATIONS SAMPLED IN SECTION F

This has resulted from the elimination of normal populations of aquatic insects and other invertebrates and their replacement by pollution-tolerant species which have limited value as fish food organisms. Another major effect is a reduction in the aesthetic quality of the river.

Normal bottom faunal communities along Algoma's loading dock and in the bay just west of the dock are disrupted. This impairment is a result of the general water and sediment degradation in that area. Three waste materials were identified in the sediments and were considered responsible for most of the damage to the bottom fauna, including iron oxide particles, wood particles and oil. The benthos towards the head of the dock is disrupted by oil, probably a result mainly of Algoma's discharges to Davignon Creek, as well as by iron oxide particles in the sediment, originating from the Algoma Steel Corporation. The benthos at the end of the dock is severely affected by iron oxide particles, which are discharged at effluent #10 (see Fig. 4a). Bottom faunal associations in the bay are unbalanced as a result of wood particles, iron oxide particles, and oil in the sediment. The wood particles come from previous logging operations in this area, iron oxide particles come from the Algoma Steel plant; most of the oil probably comes from Davignon Creek, although some may come from Bennet Creek. At the time of this survey, there appeared to be very little flow in either of these creeks. However, oil emerged from the sediment in parts of both these creeks when the bottom was disturbed, and a 'flushing' action after a heavy rain presumably would carry a considerable amount of oil into the main river.

The loading dock area and bay are isolated from the main flow of the river, and hence a lack of 'flushing' from river flow is a factor in allowing this area to deteriorate. If the accumulation of iron oxide and wood particles continues, a heavy coating could accumulate on the bottom of the bay. At present, the normal benthos has been disrupted considerably in this area, and major fish-food organisms such as mayflies and caddisflies are absent.

Immediately outside this loading dock and bay area, the effect on the benthos is negligible; it appears that much of the waste material entering via Bennet and Spring Creeks, or via discharges along Algoma's loading dock, circle into the bay and settle out.

No impairment of the bottom fauna was detected in the water flowing through the St. Mary's Falls and the canal operated by the Abitibi Power and Paper Company. Water flowing through the Abitibi Power and Paper plant is discharged into a slip which receives two waste effluents from this company. Because of the difficulty in sampling this area due to the rapid water flow, effects of these waste discharges cannot be accurately stated. However, results from one station sampled between these effluents and the trunk sewer indicated that impairment just downstream from these wastes is minor. The main problem, which affects several miles of the Canadian side of the river, arises further downstream where wood particles and fibre settle out causing physical disruption of the sediment and heavy decomposition. The benthos in many of the calm bay areas along the north shore

between the Abitibi Power and Paper plant and Sugar Island is quite seriously affected by excessive decomposition of these wastes. Aesthetic impairment is also evident in the area around stations 37, 38, 40, 41 and 45 because of the dark brown mats which float up to the surface. These mats are presumably released from the bottom by gases released upon decomposition of the fine wood chips and fibre. Wood chips were noted in the sediment on the Canadian side of the river as far downstream as Little Lake George (approximately 10 miles downstream from the Abitibi Power and Paper plant), although they were found infrequently beyond stations 55-57 (approximately 3-3/4 miles down from the Abitibi Power and Paper plant).

The major source of pollution on the river is the trunk sewer which carries wastes from the Algoma Steel plant; the flow of this sewer averages about 75 mgd. The high concentration of iron particles in this sewer disrupts the benthos at least to a distance of two and one-half miles downstream. No macroinvertebrates were found at one station located about 150 feet from the sewer where iron constituted 44% of the sediment weight. Oil and naphthalene are two other waste products from the trunk sewer which probably play a significant role in disrupting the benthos. A distinct naphthalene odour was noticed in the sediment samples as far downstream as two miles from the effluent, and high phenol concentrations in both the water and sediment were found throughout the same area.

While such wastes as wood particles and fibres, iron oxide particles, oils and naphthalene are easily recognizable as pollutants, it is the combined effect of all the wastes which disrupts the benthos. For this reason, it is difficult to specifically pinpoint the major pollutants further downstream from Sault Ste. Marie. However, it is clear that the benthos is affected by these combined industrial wastes even as far downstream as the sewage treatment plant (approximately 5 miles downstream from the trunk sewer), although recovery is fairly advanced at this point.

The effluent from the sewage treatment plant is seriously disrupting the benthos up to a distance of 1800 feet downstream from the outfall. Recovery was evident at stations located 2500 feet and 4600 feet from the effluent, and at 8500 feet the benthos was similar to that found just above the outfall. Complete recovery of the benthos is not evident until Little Lake George is reached, at which point benthic community structure was similar to that found upstream from Sault Ste. Marie. It is believed that without the entrance of the sewage treatment plant effluent, the benthos would recover from the Algoma Steel Company's and the Abitibi Power and Paper Company's wastes just beyond the location of the sewage plant. Similarly, recovery from the sewage treatment plant wastes would probably be reached earlier if the water assimilating these wastes was not impaired by industrial wastes. The combined industrial and municipal wastes, do not permit complete recovery until Little Lake George is reached.

Bottom faunal communities along the west channel of Sugar Island indicated a clean-water environment. It can therefore be concluded that wastes from the Canadian industries do not disrupt the invertebrate populations on the American side of the river.

RECOMMENDATIONS

a) Improved waste control measures should be implemented by the Algoma Steel Corporation Ltd. Special attention should be given to the removal of iron, oil, phenol, ammonia, cyanide, and naphthalene from their waste discharges.

b) Adequate waste control facilities should be developed by the Abitibi Power and Paper Company. Primary consideration should be given to the removal of wood particles and fibre.

c) Improvements to the municipal collector system and enlarged waste treatment facilities should be undertaken by the municipality.

d) The origin of oil in the sediment of Bennet Creek and Davignon Creek should be investigated, as well as the source of oil found in the sediment of the bay just up-stream from the Algoma Steel Corporation's loading dock.

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Appendix I. Macroinvertebrates (in numbers/M^2) collected at the 89 stations sampled on the St. Mary's River - July and August, 1967.

	1	2	3	4	5	6	7	8	9	10	11	12
TUBIFICIDS												
Limnodrilus												
angustipenis	4											
cervix												
claparedianus												
hoffmeisteri									10	10		
profundicola												
udekemianus							30					
(unidentified)									108			
Tubifex												
ignotus												
kessleri												
templetoni												
tubifex												
(unidentified)												
Peloscolex												
ferox							700			89	78	
freyi								10	19	93		
multisetosus												
superiorensis												
variegatus									10			
(unidentified)									10			
Aulodrilus												
americanus										40	20	
limnobius										10		
pluriseta												
pigueti												
Potamothrix												
moldaviensis												
vejdovskyi						10						
Psammoryctides												
curvisetosus												
(unidentified)						20				10	20	
LUMBRICULIDS												
Stylodrilus	10											
heringianus							78					
(unidentified	10					108	178	49	20	60	60	
ENCHYTRAEIDS		10										
NAIDIDS	10											
Arcteonais												
lomondi										10		
Nais												
variabilis												
Ophidonais												
serpentina												
Uncinais												
urcinata										10		

	1	2	3	4	5	6	7	8	9	10	11	12
NEMATODES												
FLATWORMS												
LEECHES												
Erpobdella punctata												
Dina lateralis												
Helobdella stagnalis	10											
Mooreobdella microstoma												
(unidentified)												
SNAILS												
Amnicola binneyana						10	99	20				
(unidentified)									99	945		
Campeloma												
Goniobasis livescens						20						
(unidentified)											40	99
Gyraulus									20			
Helisoma										20	40	
Lymnaea						10				10	10	
Physa												
Pyrgulopsis										10		
Valvata sincera	10									66		
Valvata tricarinata						60	99			30	30	
CLAMS												
Pisidium	10					20	20			30		
Sphaerium							20				40	
CRAYFISH												
Orconectes virilis propinquus (immature)												
AMPHIPODS												
Pontoporeia affinis		20	109	128	49					10		
Hyalella azteca	30					30	69	88			30	
ISOPODS												
Asellus							10					
Lirceus												
MIDGES	820	236	99	40	147	256	512	99	1015	739	118	
ALDERFLIES												

	1	2	3	4	5	6	7	8	9	10	11	12
CADDISFLIES												
Hydropsyche												
Limnephilus												
Mystacides			10									
Oecetis	10		10					10	20	10		
Dolophilus												
Polycentropus							30				10	
Phryganea												
Phylocentropus												
Rhyacophila												
Triaenodes												
MAYFLIES												
Hexagenia						20	522	60	89	20	99	
Ephemera							40	40	10	10	55	
Caenis									10			
STONEFLIES									10			
BLACKFLIES												

	13	14	15	16	17	18	19	20	21	22	23	24
TUBIFICIDS												
Limnodrilus												
angustipenis												
cervix									138			
claparedianus												
hoffmeisteri	40	10	10	108		20	236	20	709		10	155
profundicola												
udekemianus				10								
(unidentified)			29	246		403	276	20	1300			76
Tubifex												
ignotus												
kessleri												
templetoni			10				20					
tubifex				10		167	10		2660			
(unidentified)									1002			39
Peloscolex												
ferox	108		148		59							20
freyi	40		10								40	
multisetosus				49		49	10				20	66
superiorensis												
variegatus												
(unidentified)												20
Aulodrilus												
americanus		10									40	
limnobius												
pleuriseta				10								
piqueti	40											
Potamothrix												
moldaviensis												
vejdovskyi				10								
Psammoryctides												
curvisetosus	40				98							
(unidentified)												
LUMBRICULIDS												
Stylodrilus					10							
heringianus												
(unidentified)			10		10						10	
ENCHYTRAEIDS												
NAIDIDS												
Arcteonais												
lomondi												
Nais												
variabilis												
Ophidonais												
serpentina												
Uncinais												
urcinata												

	13	14	15	16	17	18	19	20	21	22	23	24
NEMATODES												
FLATWORMS												
LEECHES												
Erpobdella punctata												
Dina lateralis												
Helobdella stagnalis												
Mooreobdella microstoma												
(unidentified)			19									
SNAILS												
Amnicola binneyana												
(unidentified)	138	177									599	
Campeloma							10					
Goniobasis livescens												
(unidentified)											20	
Gyraulus		20									20	
Helisoma												
Lymnaea												
Physa												
Pyrgulopsis		10										
Valvata sincera												
tricarinata												
CLAMS												
Pisidium			59		10		10					38
Sphaerium					20						30	114
CRAYFISH												
Orconectes virilis												
propinquus												
(immature)												
AMPHIPODS												
Pontoporeia affinis												
Hyalella azteca	40											
ISOPODS												
Asellus					10							
Lirceus												
MIDGES	522	672	118	286	138	10	177	69			759	108
ALDERFLIES												

CADDISFLIES	13	14	15	16	17	18	19	20	21	22	23	24
Hydropsyche												
Limnephilus												
Mystacides	10											
Oecetis	30										10	
Dolophilus												
Polycentropus												
Phryganea	10											
Phylocentropus												
Rhyacophila												
Triaenodes												
MAYFLIES												
Hexagenia	158	118			49			10			69	19
Ephemera	60	10									39	
Caenis												
STONEFLIES												
BLACKFLIES												

	25	26	27	28	29	30	31	32	33	34	35
TUBIFICIDS											
Limnodrilus											
angustipenis											
cervix									29		
claparedianus											
hoffmeisteri						124	76	228		10	
profundicola						49					
udekemianus											
(unidentified)						246		39	29	10	10
Tubifex											
ignotus											
kessleri											
templetoni											
tubifex								76			
(unidentified)											
Peloscolex											
ferox						142			702		
freyi						1080					
multisetosus						29					
superiorensis											
variegatus						29					
(unidentified)									39		
Aulodrilus											
americanus											
limnobius											
pluriseta											
pigueti											
Potamothrix											
moldaviensis						29					
vejdovskyi											
Psammoryctides											
curvisetosus											
(unidentified)											
LUMBRICULIDS											
Stylodrilus	10										
heringianus											
(unidentified)	57		47								10
ENCHYTRAEIDS			76								
NAIDIDS											
Arcteonais											
lomondi											
Nais		10									
variabilis											
Ophidonais											
serpentina											
Uncinais											
urcinata											

	25	26	27	28	29	30	31	32	33	34	35
NEMATODES											
FLATWORMS											
LEECHES											
Erpobdella punctata											
Dina lateralis											
Helobdella stagnalis									10		
Mooreobdella microstoma											
(unidentified)									10		
SNAILS											
Amnicola binneyana											
(unidentified)						29			264		
Campeloma											
Goniobasis livescens											
(unidentified)						29					
Gyraulus						10					
Helisoma											
Lymnaea											
Physa											
Pyrgulopsis											
Valvata sincera tricarinata						10			86		
CLAMS											
Pisidium						39			104		
Sphaerium	114										
CRAYFISH											
Orconectes virilus propinquus											
(immature)											
AMPHIPODS											
Pontoporeia affinis											
Hyalella azteca											
ISOPODS											
Asellus				10							
Lirceus											
MIDGES	10	30	217			236			293		
ALDERFLIES											

	25	26	27	28	29	30	31	32	33	34	35
CADDISFLIES											
Hydropsyche		19									
Limnephilus											
Mystacides											
Oecetis											
Dolophilus		10									
Polycentropus											
Phryganea											
Phylocentropus											
Rhyacopila		10									
Triaenodes											
MAYFLIES											
Hexagenia						19			49		
Ephemera											
Caenis											
STONEFLIES											
BLACKFLIES											

	36	37	38	39	40	41	42	43	44	45	46
TUBIFICIDS											
Limnodrilus											
angustipenis											
cervix											
claparedianus			59	39	581	39	236				
hoffmeisteri		512	10	39	502	394	1940	502	148	1694	888
profundicola				39	54		69	10	10		
udekemianus		2600									
(unidentified)	10	5397	19	276	581	237	994	1044	49	9421	3398
Tubifex											
ignotus											
kessleri											
templetoni											
tubifex		7959	10		88						236
(unidentified)		6186	10	138	236		5181	138		30298	798
Peloscolex											
ferox							138	276			98
freyi									10		
multisetosus			10								
superiorensis											
variegatus											
(unidentified)											
Aulodrilus											
americanus											
limnobius										709	
pluriseta											
pigueti											
Potamothrix											
moldaviensis											
vejdovskyi											
Psammoryctides											
curvisetosus										157	
(unidentified)											
LUMBRICULIDS											
Stylodrilus	19			39							
heringianus											
(unidentified)				171				19		157	
ENCHYTRAEIDS				39	39						
NAIDIDS											
Arcteonais											
lomondi											
Nais											
variabilis											
Ophidonais											
serpentina											
Uncinais											
uncinata											

	36	37	38	39	40	41	42	43	44	45	46
NEMATODES											
FLATWORMS											
LEECHES											
Erpobdella punctata										39	89
Dina lateralis								10			
Helobdella stagnalis											
Mooreobdella microstoma								10			
(unidentified)			10					10			267
SNAILS											
Amnicola binneyana											
(unidentified)								10			
Campeloma											
Goniobasis livescens											
(unidentified)											
Gyraulus											
Helisoma											
Lymnaea							39	29			
Physa								29			
Pyrgulopsis											
Valvata sincera tricarinata											
CLAMS											
Pisidium							39	304		591	39
Sphaerium											
CRAYFISH											
Orconectes virilus propinquus											
(immature)											
AMPHIPODS											
Pontoporeia affinis											
Hyalella azteca											
ISOPODS											
Asellus								161			
Lirceus											
MIDGES	49		10				39	20	414		
ALDERFLIES											

	36	37	38	39	40	41	42	43	44	45	46
CADDISFLIES											
Hydropsyche											
Limnephilus											
Mystacides											
Oecetis											
Dolophilus											
Polycentropus											
Phryganea											
Phylocentropus											
Rhyacopila											
Trianenodes											
MAYFLIES											
Hexagenia											
Ephemera											
Caenis											
STONEFLIES											
BLACKFLIES											

	47	48	49	50	51	52	53	54	55	56
TUBIFICIDS										
Limnodrilus										
angustipenis										
cervix										
claparedianus			49							
hoffmeisteri			256			315	39		19	157
profundicola										
udekemianus							29			
(unidentified)			246		10	8638	29		118	589
Tubifex										
ignotus			69			128			39	
kessleri										
templetoni										
tubifex						266				
(unidentified)			152			473	10			29
Peloscolex										
ferox	256		473					79	19	275
freyi			88							197
multisetosus									10	
superiorensis						1103				
variegatus										
(unidentified)										
Aulodrilus										
americanus										
limnobius										
pluriseta										
pigueti										
Potamothrix										
moldaviensis										
vejdovskyi										
Psammoryctides										
curvisetosus										
(unidentified)										
LUMBRICULIDS										
Stylodrilus										
heringianus								69		
(unidentified)	69	98		19	49			29	117	
ENCHYTRAEIDS										
NAIDIDS										
Arcteonais										
lomondi										
Nais										
variabilis										
Ophidonais										
serpentina										
Uncinais										
uncinata										

	47	48	49	50	51	52	53	54	55	56
NEMATODES										
FLATWORMS										
LEECHES										
Erpobdella punctata										
Dina lateralis	19									
Helobdella stagnalis										
Mooreobdella microstoma										
(unidentified)	171								39	10
SNAILS										
Amnicola binneyana										
(unidentified)	49		10		285			108		
Campeloma										
Goniobasis livescens										
(unidentified)			10		29			158		10
Gyraulus						19		39		
Helisoma						10				
Lymnaea					10			49		
Physa									10	10
Pyrgulopsis					10					
Valvata sincera tricarinata	59				39	10	39	443	10	39
CLAMS										
Pisidium	29	39	29			19	10	39	69	207
Sphaerium						29	10			
CRAYFISH										
Orconectes virilus propinquus (immature)									10	
AMPHIPODS										
Pontoporeia affinis										
Hyalella azteca								39		
ISOPODS										
Asellus	79				10		10		10	
Lirceus										
MIDGES	690			39	99	10	39	49	10	39
ALDERFLIES										

	47	48	49	50	51	52	53	54	55	56
CADDISFLIES										
Hydropsyche										
Limnephilus										
Mystacides										
Oecetis										
Dolophilus										
Polycentropus										
Phryganea										
Phylocentropus										
Rhyacopila										
Trianenodes							10			
MAYFLIES										
Hexagenia	79				29					
Ephemera										
Caenis										
STONEFLIES										
BLACKFLIES				10						

	57	58	59	60	61	62	63	64	65	66	67
TUBIFICIDS											
Limnodrilus											
angustipenis										335	906
cervix											
claparedianus	29										
hoffmeisteri	89				59		20	39	591	335	1812
profundicola											
udekemianus				29		117	10	10	1182		
(unidentified)	39	149		88	128		49	20	197	2305	23561
Tubifex											
ignotus											
kessleri											
templetoni											
tubifex										5299	19030
(unidentified)	39										
Peloscolex											
ferox					99	1714	20	89			
freyi	148										
multisetosus											
superiorensis		19		10							
variegatus											
(unidentified)											
Aulodrilus											
americanus											
limnobius											
pluriseta					128			59			
piqueti											
Potamothrix											
moldaviensis											
vejdovskyi											
Psammoryctides											
curvisetosus											
(unidentified)											
LUMBRICULIDS											
Stylodrilus											
heringianus	99		10			355					
(unidentified	99		19			709	59				
ENCHYTRAEIDS											
NAIDIDS											
Arcteonais											
lomondi											
Nais											
variabilis				39							
Ophidonais											
serpentina											
Uncinais											
urcinata											

	57	58	59	60	61	62	63	64	65	66	67
NEMATODES							10				
FLATWORMS					10		20	89			
LEECHES											
Erpobdella punctata		20									
Dina lateralis											
Helobdella stagnalis											
Mooreobdella microstoma											
(unidentified)	10			20			69	197			
SNAILS											
Amnicola binneyana											
(unidentified)	19			10	29	197	10	59			
Campeloma											
Goniobasis livescens											
(unidentified)											
Gyraulus		167						49			
Helisoma											
Lymnaea			10			49					
Physa	59	29		49		10		29			228
Pyrgulopsis	118										
Valvata sincera tricarinata								49			
CLAMS											
Pisidium	98	236		49	19	138	69	276			79
Sphaerium		10									
CRAYFISH											
Orconectes virilus propinquus											
(immature)											
AMPHIPODS											
Pontoporeia affinis											
Hyalella azteca	10						20	69			
ISOPODS											
Asellus	10	49			10	10	187	611			
Lirceus								49			
MIDGES	29	158		99		237	3546	3418			
ALDERFLIES											

	57	58	59	60	61	62	63	64	65	66	67
CADDISFLIES											
Hydropsyche											
Limnephilus							10				
Mystacides											
Oecetis											
Dolophilus											
Polycentropus											
Phryganea											
Phylocentropus											
Rhyacopila											
Trianenodes											
MAYFLIES											
Hexagenia					10		10	89			
Ephemera						10	10				
Caenis								10			
STONEFLIES											
BLACKFLIES											

	68	69	70	71	72	73	74	75	76	77	78
TUBIFICIDS											
Limnodrilus											
angustipenis											
cervix											
claparedianus											
hoffmeisteri	2522	59	49	138	59	473	10	247		207	305
profundicola											
udekemianus											
(unidentified)	23955	138	113	414	59	10401	39	463		443	325
Tubifex											
ignotus		493			650				19		
kessleri											
templetoni											
tubifex	36563		10	59	118	13293		39			
(unidentified)											
Peloscolex											
ferox		158	59	768	118				10	345	265
freyi											
multisetosus					118						
superiorensis						473					
variegatus											
(unidentified)											
Aulodrilus											
americanus										49	
limnobius											
pluriseta							49				19
piqueti								39			
Potamothrix											
moldaviensis											
vejdovskyi											
Psammoryctides											
curvisetosus											
(unidentified)											
LUMBRICULIDS											
Stylodrilus											
heringianus			20						69		
(unidentified)			39		59				89		
ENCHYTRAEIDS											
NAIDIDS											
Arcteonais											
lomondi											
Nais											
variabilis											
Ophidonais											
serpentina								19			
Uncinais											
urcinata											

	68	69	70	71	72	73	74	75	76	77	78
NEMATODES											
FLATWORMS											
LEECHES											
Erpobdella											
punctata											
Dina											
lateralis											
Helobdella											
stagnalis											
Mooreobdella											
microstoma								19			
(unidentified)								39	10	158	89
SNAILS											
Amnicola											
binneyana											
(unidentified)											19
Campeloma				20						39	20
Goniobasis											
livescens											
(unidentified)											
Gyraulus											
Helisoma											10
Lymnaea									10		10
Physa	304	50						29		10	10
Pyrgulopsis											
Valvata											
sincera											
tricarinata										10	147
CLAMS											
Pisidium	158			20	138	315		10		364	384
Sphaerium										10	
CRAYFISH											
Orconectes											
virilus											
propinquus											
(immature)											
AMPHIPODS											
Pontoporeia											
affinis											
Hyalella											
azteca											
ISOPODS											
Asellus					20		10	39		483	29
Lirceus											
MIDGES			10				276	10	20	69	99
ALDERFLIES							10				

	68	69	70	71	72	73	74	75	76	77	78
CADDISFLIES											
Hydropsyche											
Limnephilus											
Mystacides											
Oecetis											
Dolophilus											
Polycentropus											
Phryganea											
Phylocentropus											
Rhyacopila											
Trianenodes											
MAYFLIES											
Hexagenia							217				
Ephemera											
Caenis							10				
STONEFLIES										10	
BLACKFLIES											

	79	80	81	82	83	84	85	86	87	88	89
TUBIFICIDS											
Limnodrilus											
angustipenis											
cervix											
claparedianus											
hoffmeisteri		492		39			19	482	10	19	
profundicola											
udekemianus											
(unidentified)		936		20				1142		39	59
Tubifex											
ignotus											
kessleri											
templetoni											
tubifex											
(unidentified)											
Peloscolex											
ferox		187	10	19					10	39	20
freyi											
multisetosus											
superiorensis							10				
variegatus											
(unidentified)											
Aulodrilus											
americanus							19			10	
limnobius				10							
pluriseta							89	49		19	
pigueti											
Potamothrix											
moldaviensis											
vejdovskyi											
Psammoryctides											
curvisetosus											
(unidentified)											10
LUMBRICULIDS											
Stylodrilus											
heringianus											
(unidentified)			69	20		69	207		10	138	49
ENCHYTRAEIDS											
NAIDIDS											
Arcteonais											
lomondi											
Nais											
variabilis											
Ophidonais											
serpentina											
Uncinais											
urcinata											

	79	80	81	82	83	84	85	86	87	88	89
NEMATODES											
FLATWORMS		59	10								
LEECHES											
Erpobdella punctata											
Dina lateralis											
Helobdella stagnalis											
Mooreobdella microstoma	197	10				39		20		20	
(unidentified)											
SNAILS											
Amnicola binneyana											
(unidentified)											
Campeloma											
Goniobasis livescens											
(unidentified)											
Gyraulus											
Helisoma											
Lymnaea											
Physa											
Pyrgulopsis											
Valvata sincera tricarinata											
CLAMS											
Pisidium											
Sphaerium											
CRAYFISH											
Orconectes virilus propinquus											
(immature)											
AMPHIPODS											
Pontoporeia affinis											
Hyalella azteca											
ISOPODS											
Asellus		916				49	79			89	
Lirceus			108							19	
MIDGES		79	10	39	118	89	177	122	99	89	49
ALDERFLIES					39						

	79	80	81	82	83	84	85	86	87	88	89
CADDISFLIES											
Hydropsyche											
Limnephilus											
Mystacides											
Oecetis											
Dolophilus											
Polycentropus				10							
Phryganea											
Phylocentropus											
Rhyacopila							10				
Trianenodes											
MAYFLIES											
Hexagenia			211	315	1202	276	10		20	39	
Ephemera			20	10		59			108	20	541
Caenis											10
STONEFLIES											
BLACKFLIES											

*Appendix II. Results of the chemical analyses of samples collected on the St. Mary's River - July and August, 1967.

	Stations							
Bottom Water	5	6	9	10	12	14	16	17
BOD_5			1.4				0.4	0.5
Total solids	45	44	120	90	36	52	102	66
Susp. solids	5	1	7	5	3	4	10	2
Diss. solids	40	43	113	85	33	48	92	64
Free NH_3	0.08	0.08	0.03	0.08	0.06	0.03	0.23	0.10
Total kjeldahl	0.20	0.13	0.33	0.20	0.13	0.33	0.39	0.26
Nitrite	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Nitrate	0.18	0.17	0.22	0.22	0.17	0.22	0.05	0.06
Total phos. (as PO_4)	0.13	0.01	0.01	0.04	0.01	0.01	.045	.120
Iron (as Fe)	0.05	0.19	0.22	0.08	0.05	0.11	0.34	0.75
Phenols (ppb)	0	2	2	0	0	0	2	0
Cyanide (as HCN)	-	-	-	-	-	-	0.0	-
Sulphate	-	-	-	-	-	-	2.0	-
Sediment								
Ether sol. oils (%)	-	-	-	-	-	-	0.11	0.01
Iron (Fe_2O_3) (%)	-	-	-	-	-	-	7.57	0.89
Phenols (ppb)	-	-	-	-	-	-	2500	2500

*All results in parts per million unless otherwise stated.

Appendix II. continued

Bottom Water	Stations 18	19	20	21	22	23	24	25
BOD_5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total solids	56	88	64	70	64	62	74	74
Susp. solids	2	5	1	1	3	2	1	4
Diss. solids	54	83	63	69	61	60	73	70
Free NH_3	0.02	0.23	0.02	0.02	0.06	0.10	0.08	0.16
Total kjeldahl	0.39	0.33	1.10	0.39	0.20	0.26	0.39	0.33
Nitrite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitrate	0.05	0.05	0.08	0.06	0.05	0.16	0.06	0.17
Total Phos. (as PO_4)	.015	.200	.145	.015	0.21	0.35	.020	.015
Iron (as Fe)	0.34	0.80	0.11	0.08	0.55	0.09	0.63	0.45
Phenols (ppb)	0.00	0.00	0.00	2	0.00	0.00	8	0.00
Cyanide (as HCN)	-	-	-	-	0.00	0.00	-	-
Sulphate				4.0	-	0.00	-	-

Sediment	18	19	20	21	22	23	24	25
Ether sol. oils	1.16	0.53	0.16	0.24	0.27	0.04	0.17	0.10
Iron (Fe_2O_3) (%)	6.97	5.97	5.1	6.5	25.4	0.90	10.6	1.74
Phenols (ppb)	4000	1500	2000	2500	1200	1200	1500	3000

Appendix II. continued

Bottom Water	Stations 26	28	29	30	31	32	33	34
BOD_5	0.4	-	-	-	3.1	-	1.3	2.7
Total solids	68	40	324	-	54	-	32	52
Susp. solids	3	8	25		7	-	4	9
Diss. solids	65	32	299	-	47	-	28	43
Free NH_3	0.02	0.13	0.33	-	0.39	-	0.12	0.43
Total kjeldahl	0.39	0.46	0.84	-	1.43	-	0.40	0.98
Nitrite	0.00	.006	.007	-	.007	-	.005	.008
Nitrate	0.00	0.10	0.15	-	0.04	-	0.15	0.08
Total Phos. (as PO_4)	.025	0.08	0.06	-	0.26	-	0.04	0.05
Iron (as Fe)	0.15	0.23	0.42	-	0.50	-	0.14	0.45
Phenols (ppb)	0.00	4	100	-	100	-	2	100
Cyanide (as HCN	0.00	0.00	0.09	-	-	-	-	0.12
Sulphate	2.0	0.00	2.0	-	-	-	-	0.00

Sediment	26	28	29	30	31	32	33	34
Ether sol. oils	-	-	0.51	0.11	2.59	0.82	0.04	-
Iron (Fe_2O_3) (%)	-	-	44.2	3.17	27.4	29.9	-	-
Phenols (ppb)	-	-	1600	1200	12000	2000	1200	-

Appendix II. continued

Bottom Water	35	36	37	38	39	40	41
	Stations						
BOD_5	1.9	1.7	1.8	1.3	0.6	1.3	-
Total solids	54	36	32	34	46	26	-
Susp. solids	8	6	6	6	4	5	-
Diss. solids	45	30	23	-	42	21	-
Free NH_3	0.39	0.30	-	-	-	-	-
Total kjeldahl	0.46	0.46	-	-	-	-	-
Nitrite	.005	.005	-	-	-	-	-
Nitrate	0.10	0.10	-	-	-	-	-
Total Phos. (as PO_4)	0.03	0.03	0.06	0.04	0.05	0.05	-
Iron (as Fe)	0.25	0.18	0.40	0.33	0.10	0.45	-
Phenols (ppb)	40	30	100	100	2	100	-
Cyanide (as HCN)	0.02	0.02	-	-	-	-	-
Sulphate	-	-	-	-	-	-	-

Sediment	35	36	37	38	39	40	41
Ether sol. oils	-	-	0.15	0.87	0.18	0.39	0.14
Iron (Fe_2O_3) (%)	-	-	12.7	5.5	4.9	3.5	5.9
Phenols (ppb)	-	-	1200	15000	1200	20000	20000

Appendix II. continued

Bottom Water	Stations 42	43	45	46	47	49
BOD_5	-	-	-	2.9	1.4	0.8
Total solids	-	-	-	26	40	46
Susp. solids	-	-	-	6	5	4
Diss. solids	-	-	-	20	35	42
Free NH_3	-	-	-	0.23	0.13	0.16
Total kjeldahl	-	-	-	0.46	0.20	0.52
Nitrite	-	-	-	.006	.004	.005
Nitrate	-	-	-	0.10	0.15	0.10
Total Phos. (as PO_4)	-	-	-	0.04	0.04	0.03
Iron (as Fe)	-	-	-	0.43	0.13	0.25
Phenols (ppb)	-	-	-	100	4	4
Cyanide (as HCN)	-	-	-	0.06	-	-
Sulphate	-	-	-	-	-	-

Sediment	42	43	45	46	47	49
Ether sol. oils	0.63	0.37	0.75	1.17	0.16	0.02
Iron (Fe_2O_3) (%)	2.2	-	7.4	10.4	0.01	1.1
Phenols (ppb)	25000	12000	12000	12000	1200	800

Appendix II. continued

Bottom Water	Stations 65	68	69
BOD_5	15	6.3	1.2
Total solids	162	60	-
Susp. solids	20	7	10
Diss. solids	142	53	-
Free NH_3	4.6	0.05	0.10
Total kjeldahl	-	3.10	0.58
Nitrite	.015	0.13	.006
Nitrate	0.10	0.39	0.30
Total Phos. (as PO_4)	0.15	1.20	0.12
Iron (as Fe)	1.02	0.48	0.36
Phenols (ppb)	30	4	4
Cyanide (as HCN)	-	-	-
Sulphate	-	-	-
Sediment			
Ether sol. oils	-	-	-
Iron (Fe_2O_3) (%)	-	-	-
Phenols (ppb)	-	-	-